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1917

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THE DEPARTMENT OF AGRICULTURE AND LABOR
UNDER THE DIRECTION OF
W. V. TOWER,
DIRECTOR, INSULAR EXPERIMENT STATION
RIO PIEDRAS, P. R.
JOHN A. STEVENSON, EDITOR.

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A LIST OF THE COCCIDAE OF PORTO RICO.

By Thomas H. Jones,

Formerly Entomologist of the Experiment Station of the Board of Commissioners of Agriculture of Porto Rico.

From time to time various entomological workers have published references to the *Coccidae* of Porto Rico, but the list of twenty-three species collected on the island in 1899 by Mr. August Busck is, so far as known to the writer, the only attempt ever made to enumerate the Porto Rican scale-insects. This list appeared in 1900 in Bulletin No. 22, new series, of the Division of Entomology, United States Department of Agriculture, the determinations having been made by Messrs. T. Pergande, T. D. A. Cockerell, and C. L. Marlatt. In connection with this list it is stated that only one coccid, *Aspidiotus destructor*, had been previously recorded from Porto Rico, this being in a reference in the *Canadian Entomologist* for 1895, the material having been taken by Mr. J. D. Hall in the city of San Juan.

Some of the *Coccidae* of the island, especially those attacking citrus trees, are referred to somewhat fully in the publications of the Porto Rico Agricultural Experiment Station. In these articles Messrs O. W. Barrett and W. V. Tower have treated the greatest number of species and given the most extended economic accounts.

Much attention has been given to the parasitic fungi attacking the scale-insects of citrus trees by the workers of the Porto Rico Insular Experiment Station. They have recommended the planting of windbreaks in orchard areas to furnish suitable conditions for the development of these fungi, which under favorable circumstances become very efficient enemies of the scale-insects. Mr. J. R. Johnston published in 1915 a bulletin on the entomogenous fungi of the island, and in it made several references to those attacking *Coccidae*. The insect parasites and predators of Porto Rican scale-insects have, on the other hand, received but little attention. Messrs. O. W. Barrett, F. S. Earle, and D. L. Van Dine mention parasites of *Lepidosaphes beckii*, *Saissetia hemisphaerica*, and *Aspidiotus sacchari*, respectively, but do not give their scientific names. Apparently the only insect enemies of the scale-insects specifically recorded from Porto Rico are *Aspidiotiphagus citrinus* and *Cocci-*

doxenus portoricensis. The former is mentioned in the following statement by Mr. E. K. Carnes, which appeared in the Monthly Bulletin of the State Commission of Horticulture of California, Vol. 1, No. 8, page 398. In connection with data on the introduction of beneficial insects into California, Mr. Carnes states: "From Prof. C. W. Hooker, Mayagüez, Porto Rico. First shipment: *Lepidosaphes beckii, Chrysomphalus aonidum. Aspidiotiphagus citrinus* issued in considerable numbers. Second shipment: same material. Very few *A. citrinus* issued." *Coccidoxenus portoricensis* was described by Mr. J. C. Crawford from "the wax scale," collected in San Juan by Mr. Tower.[1]

This scarcity of references would indicate—considering what has already been published on the scale-insects of the island—that this group has few insect enemies in Porto Rico. This, however, is not the case, parasitism of many species being common.

In the present paper the idea has been to list all the species previously recorded from the island, with the locality, host-plant, the name of the writer, and a reference to the publication from which the data is taken. Added to this are the names of the species not heretofore recorded from Porto Rico, as well as new host-plants and localities for those already known to be present. No attempt has been made to include those species mentioned by other writers by genus or common names only, and where no more definite locality than "West Indies," with reference to any species, is given in a publication, that species has been omitted. While no endeavor has been made to summarize what has already been done on the island on the life-histories of the various species, natural and artificial methods of control, etc., I believe the bibliography is quite complete and the reader will find much of interest in the publications mentioned.

The data now presented for the first time are taken from the notes and specimens in the collection formerly belonging to the Experiment Station of the Porto Rico Sugar Producers' Association, and now at the Experiment Station of the Board of Commissioners of Agriculture of Porto Rico. All of the specimens have been examined by Mr. E. R. Sasscer, formerly of the United States Bureau of Entomology, and now with the Federal Horticultural Board. The writer wishes especially to thank Mr. Sasscer for his kindness in making the determinations and reading over the manuscript. Without his assistance the publication of this list would not have been possible. I wish also to thank Mr. D. L. Van Dine, formerly

[1] Descriptions of New Hymenoptera, No. 6, No. 1979. From Proc. U. S. Nat. Mus. Vol. 45, pp. 241–260. May 22, 1913. pp. 248–249.

Entomologist of the Experiment Station of the Porto Rico Sugar Producers' Association, and Mr. J. R. Johnston, formerly Plant Pathologist of the same station. Both have collected a number of species and Mr. Johnston has made the determinations of many of the host-plants. Since the time of my leaving Porto Rico my successor, Mr. G. N. Wolcott, has added some data to the list. Mr. R. T. Cotton of the same station, and Mr. R. H. Van Zwaluwenburg, Entomologist of the Porto Rico Agricultural Experiment Station at Mayagüez, have also added a number of new records from recent determinations.

The system that has been followed in making up the bibliography may be explained as follows: After each reference to records of other writers in the text, one or more numbers will be found in parentheses. The first number refers to the number preceding the author's name in the "Bibliography," found at the end of the list. The number, or the numbers, that may follow the first number indicates the page, or pages, on which the particular reference will be found.

In preparing the list Mrs. Fernald's catalogue of the *Coccidae* of the world has been followed. Special effort has been made to give the correct Latin names of the host-plants with the heretofore unpublished notes. The local Spanish common names of plants, given in quotations, are from the "Flora Portoricensis," by Professor Ignatius Urban, and the paper by Cook and Collins, "Economic Plants of Porto Rico," published by the Smithsonian Institution.

Subfamily *Monophlebinae*.

Icerya montserratensis Riley and Howard.

Mr. Busck collected it in 1899 "on orange, Mayagüez, January 20," and on the same host at Bayamón. (2–92.) Mr. Tower recorded it in 1908 on the orange. (16–38.) Taken at Santurce (near San Juan) on twigs and undersides of leaves of an undetermined tree; at Río Piedras on the undersides of leaves of "caimito," *Chrysophyllum argenteum* Jacq., and at Mayagüez on "maricao" (*Byrsonima spicata*), *Casearia sylvestris*, coconut palm (*Cocos nucifera*), "guamá" (*Inga laurina*), "guava" (*Inga vera*), "saman" (*Pithecolobium saman*), and guava or "guayaba" (*Psidium guajava*).

Subfamily *Ortheziinae*.

Orthezia insignis Dougl.

Collected on an undetermined plant at Dorado, on *Eupatorium*

odoratum at Comerío, on Gignonia sp. and *Ipomoea tilliacea* at Río Piedras, and on Coleus sp., *Hamelia patens, Ipomoea fastigiata, Lactuca* sp. and *Lantana camara* at Mayagüez.

SUBFAMILY *Conchaspinae.*

Conchaspis angraeci Ckll.

Found on branches of an ornamental croton (*Codiaeum* sp.), in garden at Mameyes.

SUBFAMILY *Dactylopiinae.*

Asterolecanium aureum Bdv.

Taken by Mr. Busck on the leaves of "a fiber plant" in San Juan in 1899. (2–92.)

Asterolecanium bambusae Bdv.

Collected by Mr. Busck "on bamboo" at Bayamón and at Utuado. (2–92.) The writer has taken it on bamboo at Río Piedras.

Asterolecanium lanceolatum Green.

Taken on leaves of bamboo at Río Piedras.

Asterolecanium pustulans (Ckll.)

Mr. Busck took this species "on *Anona muricata*" at San Juan and "on some leguminous plant" at Guayama. (2–92.) Mr. Barrett reported it in 1904 on the fig (*Ficus carica*) at the Mayagüez Experiment Station (1–446) and Mrs. Fernald records it from Porto Rico. (6–52.) It has been found on "escoba" (*Sida antillensis*) and "jazmín" (*Jasminum sambac*) at Río Piedras by the writer, and on *Grevillea robusta, Castilloa* sp., and *Inga vera* at Mayagüez.

Phenacoccus gossypii Towns. and Ckll.

Collected "on cotton," Humacao, by Mr. Busck. Following the data there is the note, "New to the West Indies." (2–92.) In 1902 Mr. H. Maxwell-Lefroy, in an article on scale-insects of the West Indies, gave "Porto Rico" after *Phenacoccus helianthi* var. *gossypii.* (14–298.)

Pseudococcus calceolariae (Mask.).

Mr. E. E. Green, the well-known authority on *Coccidae*, after examining specimens of sugar-cane mealy-bugs sent him from Río

Piedras, stated that they "agreed exactly with examples of *Pseudococcus calceolariae* Mask.," his determination being based "upon comparison with typical examples received from the late Mr. Maskell himself." (12–461.) Mr. Johnston records the fungus, *Aspergillus flavus,* as occurring on this mealy-bug in Porto Rico. (11–14.)

Pseudococcus citri (Risso.).

Mr. Barrett mentioned this mealy-bug (as *Dactylopius citri*) in 1904 as an enemy of citrus stock with the note, "is not common." (1–445.) Mr. Tower has published concerning it as a pineapple pest (20) and Dr. C. W. Hooker mentioned its occurrence in coffee plantations. (10–35, 37.)[1]

I have taken specimens of a mealy-bug, which Mr. Sasscer states is close to *Pseudococcus citri,* on the roots of three plants at Río Piedras. They were as follows: celery (*Apium graveolens*), corn or "maíz" (*Zea mays*), and a grass, probably *Sporobolus jacquemontii.*

Pseudococcus nipae (Mask.).

This is probably the most omniverous mealy-bug on the island. It has been collected as follows: on coconut palm (*Cocos nucifera*), Santurce; on guava or "guayaba" (*Psidium guajava*), on *Anthurium acaule,* on sour-sop or "guanábano" (*Anona muricata*), on "caimito" (*Chrysophyllum argenteum*), and on *Musa paradisiaca* var.,[2] Río Piedras; on sea grape or "uvero" (*Coccoloba uvifera*) and on "aguacate" (*Persea gratissima*) at Naguabo.

According to Mr. Johnston, the fungi, *Cephalosporium lecanii* and *Empusa fresenii,* occur on this mealy-bug. (11–19, 21.)

Pseudococcus sacchari (Ckll.).

Mealy-bugs are important pests of sugar cane in Porto Rico and practically all previous references regarding them are listed under this species. Listed as *Dactylopius sacchari,*' it was taken by Mr. Busck "on sugar cane" at Bayamón, Mayagüez, and at Humacao in 1899 (2–92), and it is recorded by Mrs. Fernald from Porto Rico. (6–109.) Mr. Van Dine published references to its occurrence on

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[1] Doctor Hooker stated that the ant, *Myrmelachista ambigua ramulorum* Wheeler, feeds on the honey-dew secreted by this mealy-bug. What is more interesting, however, is the accompanying statement made by Doctor Hooker, regarding the connection between this ant and "a large, fleshy, pink scale of the subfamily Coccinae, probably as yet undescribed." He observed that these Coccids "are carried by the ants into canals eaten out along the pith of the smaller new growth which will bear the next season's fruit. The growth is thus weakened to such an extent that when bent down by the pickers at the next harvest it breaks easily." Much of the coffee is thus lost.

[2] I have not tried to distinguish between the varieties of *Musa paradisiaca,* commonly known in English as bananas and plantains and in Spanish as "guineos" and "plátanos."

the island in 1911 (21–18, 29), 1912 (22–19, 20), and 1913 (23–251, 252, 253, 255, 256). (24–31.)

Dr. E. P. Felt has described a cecidomyiid, *Karschomyia cocci* (5–304), the larvae of which were taken by Mr. Van Dine in colonies of *Pseudococcus sacchari* (?) on sugar cane.

Chaetococcus bambusae (Mask.).

Collected on "Bamboo" at Mayagüez.

SUBFAMILY *Coccinae*.

Pulvinaria psidii Mask.

This species is often very abundant on the "jobo" tree. Mr. Tower reported it on orange and coffee. (16–38.)

We have taken it as follows: On mango (*Mangifera indica*), Río Piedras; on guava or "guayaba" (*Psidium guajava*), Río Piedras and Luquillo; on hog plum or "jobo" (*Spondias lutea*), Arroyo and Río Piedras; on a tree, *Rauwolfia tetraphylla*, Ponce.

Ceroplastes ceriferus (Anderson).

Collected on "almacigo" (*Elaphrium simaruba*) at Santa Rita, near Guánica, and on "yerba de San Martín" (*Sauvagesia erecta*) at Naguabo.

Ceroplastes cirripediformis Comst.

Found on an undetermined plant at Algarrobo.

Ceroplastes floridensis Comst.

Taken by Mr. Busck "on *Anona reticulata*." (2–92.) Mr. Barrett records it in 1904 as an enemy of citrus stock (1–445) and Mr. Tower in 1908 reported it "on the rose and orange." (16–38.) It has also been taken on *Rapanea guianensis* and *Ficus laevigata* at Río Piedras and on guava or "guayaba" (*Psidium guajava*) and mango (*Mangifera indica*) at Mayagüez.

Vinsonia stellifera (Westw.).

This interesting scale, the so-called "star-scale," is often present on the leaves of the rose apple, mango, and coconut. Mr. Busck took it on the latter host at "Catana" (probably a misspelling of Cataño) and Arroyo. (2–92.) Later, in 1904, it is mentioned by Mr. Barrett as occurring "commonly on the coconut" (1–447), and

the following statement by the same author may refer to this species, "An undetermined scale (Vinsonia?) occurs on the rose apple (*Jambos jambos*)." (1–446.)

It has further been taken as follows: On coconut palm (*Cocos nucifera*) Santurce; on "pomarrosa" or rose apple (*Jambos jambos*), Río Piedras and Mameyes; on mango (*Mangifera indica*), Santa Isabel; on *Agave sisalana, Musa* sp. and on guava or "guayaba" (*Psidium guajava*) at Mayagüez.

Inglisia vitrea Ckll.

On West Indian pigeon pea or "gandul" (*Cajanus indicas*) at Mameyes and at Comerío; on "achiote" (*Bixa orellana*) at Río Piedras.

Coccus hesperidum (Linn.).

Collected on "maguey" (*Agave sisalana*), at Río Piedras.

Coccus mangiferae (Green).

Collected on leaves of "pomarrosa" or rose apple (*Jambos jambos*) at Río Piedras; on mango (*Mangifera indica*) and *Cinnamomum zeylanicum* at Mayagüez. A fungus (*Cephalosporium lecanii*) is mentioned by Mr. Johnston as being common on this scale. (11–19.)

Saissetia hemisphaerica (Targ.).

A very comon species. Mr. Busck took it in 1899 as follows, the species being recorded as *Lecanium hemisphaericum:* "On eggplant. Catana, January 10." (2–92.) Mr. Barrett records it (as *Lecanium hemisphaericum*) on coffee, on "guanábano" (*Anona muricata*), on cassava, and states that it is "probably the most common scale on the orange here." (1–444, 445, 446, 447.) In the same year, 1904, Mr. Earle reported this species (as *Lecanium hemisphaericum*) as occurring on the orange and also wrote that a "Lecanium (probably *L. hemisphaericum*) is also at times abundant and destructive" to coffee. (4–458, 459, 463.) In 1906 Mr. van Leenhoff, Jr., mentioned *Saissetia hemisphaerica* as an enemy of coffee. (25–46.) Mr. Tower wrote of its injuries to citrus trees in 1907 (15–26), 1908 (16–32), 1909 (17–23) and 1911 (19–15). The writer has recorded it from eggplant. (13–4.)

The following records are to be added: On "jasmin" (*Gardenia jasminoides*), the introduced pepper tree (*Schinus molle*), rose apple or "pomarrosa" (*Jambos jambos*), a cultivated shrub (*Graptophyllum pictum*), and alligator pear or "aguacate" (*Persea gratis-*

sima), Río piedras; on "marunguey" (*Zamia integrifolia*), Vega Alta; on *Sida* sp., on black nightshade or "mata-gallinas" (*Solanum nigrum* var. *americanum*), and on guava or "guayaba" (*Psidium guajava*), Luquillo; on coffee or "café" (*Coffea arabica*), and *Thunbergia erecta*, Mameyes; on "orozuz" or "pascueta" (*Leptilon canadense*), Ciales; on *Rauwolfia tetraphylla*, Ponce; on *Antigonon leptopus*, *Drypetes glauca*, and *Solanum seaforthianum* at Mayagüez.

Mr. Johnston records a fungus (*Cephalosporium lecanii*) as occurring on this scale. (11–19.)

Saissetia nigra (Nietn.).

Taken by Mr. Busck in 1899 as follows, being recorded as *Lecanium nigrum*: "On *Terminalia catappa*, San Juan, January 5. On cotton, San Juan, January 5 (var. *depressum* Targ.)." (2–92.) In Mrs. Fernald's catalogue this species is recorded from Porto Rico. (6–204, 205.)

Collected in addition as follows: On "anamú" or "cadillo pequeque" (*Pavonia typhalea*), Canóvanas; on cotton or "algodón" (*Gossypium barbadense*), Guánica; on China berry or "lilaila" (*Melia azedarach*), Fortuna (near Ponce); on the introduced pepper tree (*Schinus molle*), Río Piedras; on black nightshade or "mata-gallinas" or "yerba mora" (*Solanum nigrum* var. *americanum*), on *Sida* sp., and on China berry (*Melia azedarach*), Luquillo; on *Euphorbia sanguinea* at Mayagüez.

Doctor Howard has determined as *Arrhenophagus chionaspidis* Auriv. a parasite reared from material on which *Saissetia nigra* and *Hemichionaspis minor* were present.

Saissetia oleae (Bern.).

In 1899 Mr. Busck took this species "on Calabassa tree, Lares, January 25. On honey locust, Adjuntas, January 30. On *Guazuma ulmifolia*, Guayama, February 4. On *Terminalia catappa*, Mayagüez, January 20." The genus is given as *Lecanium*. (2–92.)

Mr. Johnston collected *Saissetia oleae* on "madre de cacao" (*Erythrina glauca*) at Río Piedras, and it has been taken by the writer on "almendra" (*Terminalia catappa*) at Guánica. It has also been taken on orange oleander (*Nerium oleander*) and "berengena cimarrona" (*Solanum torvum*) at Mayagüez.

Aclerda tokionis (Ckll.).

Collected on stalk of sugar cane at Río Piedras.

Subfamily *Diaspinae*.

Chionaspis citri Comst.

This species is one of the most injurious scale-insect pests of the citrus groves in Porto Rico. It was collected by Mr. Busck in 1899 "on lime" at Añasco (2–93) and is probably generally distributed over the island. It has been treated by Messrs. Barrett (1–445), Henricksen (8–27) and Tower (17–24, 25) (19–14, 15) in various publications of the Porto Rico Agricultural Experiment Station as an enemy of citrus trees.

Doctor Howard has determined a parasite reared by the writer from *Chionaspis citri* as *Aspidiotiphagus citrinus* (Craw.).

Howardia biclavis (Comst.).

Collected by Mr. Busck "on *Bixa orellana*" at San Sebastián and Añasco. (2–93.) I have taken it on the same host, which is known as "achiote," "achote," and "annato," at Río Piedras, and in addition it has been collected as follows: On "caimito" (*Chrysophyllum cainito*), and "mamey" (*Mammea americana*), Mameyes; on "algarrobo" (*Hymenaea courbaril*), on *Casearia arborea*, on silver oak, an introduced tree (*Grevillea robusta*), and on West Indian pigeon pea or "gandul" (*Cajanus indicus*), Río Piedras; on "palo de cucubano" (*Guettarda scabra*) and *Cordia* sp., Dorado: on "roble" (*Tecoma pentaphylla*) and *Acalypha wilkesiana* at Naguabo: on sapodilla or "níspero" (*Achras sapota*), *Coffea arabica*, *Dorgalis cafra*, and *Plumiera rubra* at Mayagüez.

Diaspis echinocacti (Bouché.).

Mrs. Fernald records this species from Porto Rico. As food-plants in the various countries, where it occurs, the following are given: *Opuntia ficus-indica*, *Echinocactus ottonis*, *E. tenuispinus*, etc. (6–229, 230.) Mr. Busck lists *Diaspis calyptroides* Costa var. *opuntiae* Ckll. as having been collected at Ponce. (2–93.)

Aulacaspis pentagona (Targ.).

As is true elsewhere where it occurs, this coccid has a long list of food-plants in Porto Rico. Among cultivated plants the "papaya" or papaw suffers especially from its attacks.

In 1899 Mr. Busck took it "on castor-oil plant, Río Piedros (perhaps a misspelling of Río Piedras), January 17. On unknown tree, Bayamón, January 16. On peach, Adjunetas (probably Ad-

juntas), January 24. On honey locust, January 30. On mahagua, Fajardo, February 17." (2–93.) Mr. Earle in 1904 reported that it "occurs very commonly on the orange, as well as on various other trees and plants" (4–458) and that a scale, probably this species, was "killing a great many of the (papaw) trees." (4–467.) Mr. Barrett in the same year wrote, "very destructive to peach trees in the east part of the island; this species also attacks mulberry and papaw." (1–446.) In 1907 Mr. Tower stated, "very abundant all over the island, infesting peach, plum, mulberry, papaw, castor bean and other plants." (15–27.) The writer has recorded it from okra and pepper. (13–4.)

It has also been taken as follows: On willow (*Salix* sp.), Ponce; on "bruja" (*Bryophyllum pinnatum?*), Comerío; on "papaya" (*Carica papaya*), on West Indian pigeon pea or "gandul" (*Cajanus indicus*), Río Piedras; on "majagua" (*Paritium tiliaceum*), Mameyes; on "cadillo" (*Urena lobata*), Dorado; on castor bean or "higuerete" (*Ricinus communis*), Ciales; on "mamey" (*Mammea americana*) at Naguabo; on okra, *Hyptis* sp., *Solanum torvum*, *Trema micrantha*, and *Acalypha wilkesiana* at Río Piedras; on *Mangifera indica*, *Erythrina* sp. and oleander (*Nerium oleander*) at Mayagüez; on "emajagua" (*Paritium tiliaceum*), Adjuntas, and on cassava (*Manihot utilissima*) at Añasco.

Hemichionaspis aspidistrae (Sign.).

Collected on leaves of fern (*Nephrolepsis exaltata* var. *bostoniensis*), at Río Piedras.

Hemichionaspis minor (Mask.).

A common species, sometimes found in company with *Saissetia nigra* (Nietn.), and *S. hemisphaerica* (Targ.). Taken by Mr. Busck "on eggplant, Catana, January 17. On *Guazuma ulmifolia*, Guayama, February 4" in 1899, being listed as *Chionaspis (Hemichionaspis) minor*. (2–93.) The writer has also recorded it from eggplant. (13–4.)

It has been taken as follows: On cotton or "algodón" (*Gossypium barbadense*), Guánica; on China berry or "lilaila" (*Melia azedarach*), Fortuna (near Ponce); on "yerba rosario" (*Aeschynomene sensitiva*) and ornamental croton (*Codiaeum* sp.), Naguabo; on "verbena" (*Valerianodes jamaicensis*), Río Piedras; on "berengena cimarrona" (*Solanum torvum*) and "cadillo" (*Triumfetta semitriloba*), Luquillo; on *Lantana involucrata* at Mameyes; on *Asparagus sprengeri* and "saman" (*Pithecolobium saman*) at Mayagüez.

Doctor Howard has determined as *Arrhenophagus chionaspidis* a parasite reared from material on which *Hemichionaspis minor* and *Saissetia nigra* were present.

Pinnaspis buxi (Bouché.).

Collected on leaves of a tree epiphyte belonging to the family *Bromeliaceae* at Mameyes; on *Philodendron* sp., Ciales; on "corozo" palm (*Acrocomia media*) and another palm (*Areca lutescens*) at Río Piedras.

Leucaspis indica Mar.

Collected on mango (*Mangifera indica*) at Mayagüez.

Aspidiotus cyanophylii Sign.

On a blue gum (*Eucalyptus* sp.) at Naguabo.

Aspidiotus destructor Sign.

Apparently the first scale-insect recorded from Porto Rico, this species is very common, especially on the undersides of the leaves of coconut palms. It is often so abundant on the older leaves of these palms that they turn yellow and die. It was first recorded in the Canadian Entomologist for 1895, page 261, by Mr. T. D. A. Cockerell, the specimens having been collected in San Juan by Mr. J. D. Hall. Mr. Busck took it "on banana leaves" at "Catana," and on the same host at San Juan and Arroyo. (2–93.) Mr. Barrett in 1904 stated that at Ponce many of the coconut trees were "dead or dying from attacks" of this coccid. (1–447.)

Mr. Van Dine collected *Aspidiotus destructor* from coconut palm (*Cocos nucifera*) at Santurce, and it has further been collected as follows: On silk oak (*Grevillea robusta*), on guava or "guayaba" (*Psidium guajava*), on *Musa paradisiaca* var., Río Piedras; on alligator pear or "aguacate" (*Persea gratissima*), Mameyes and Guayama; alligator apple (*Anona palustris*) and *Mammea americana*, Río Piedras; and on date palm (*Phoenix dactylifera*), Mayagüez.

Dr. Howard has examined a parasite reared from this scale by the writer and states that it "is apparently my *Aphelinus diaspidis*."

Aspidiotus forbesi Johnson.

Listed by Mrs. Fernald as occurring in Porto Rico and fifteen food-plants are given for the species in the countries where it is

known to occur. With the possible exception of "Jasmine," no tropical plants are included in the list. (6–259, 260.)

Aspidiotus lataniae Sign.

Collected on *Castilla* sp. at Mayagüez.

Aspidiotus sacchari Ckll.

Mentioned by Mr. Van Dine in 1911 (21–19, 31), 1912 (22–22) and 1913 (23–251, 257) (24–34) as occurring on sugar cane. It is a common but not serious enemy of this host. Mr. Van Dine has collected it at Guánica, Fortuna (near Ponce), Fajardo, and Canóvanas, and in addition it has been collected at Río Piedras and Humacao, all collections having been made from sugar cane. According to Mr. Hood, Mr. Sasscer stated that it occurred with *Odonaspis* sp. which I took on the stalks of para grass or "malojillo" (*Panicum barbinode*) at Guánica. (9–70.)

Pseudaonidia tesserata (de Charm.).

From garden rose at Mameyes.

Selanaspidus articulatus (Morg.).

Collected by Mr. Busck "on orange leaves, El Yunque, February 18; about 2,000 feet altitude" in 1899. (2–93.) Has been mentioned by Mr. Barrett (1–445) and Mr. Tower (16–38) as an enemy of citrus trees. Mr. Tower, in 1909, stated that "*Pseudaonidia articulatus*" was "causing a little trouble" as an orange pest. (17–25.)

Taken by the writer on rose apple or "pomarrosa" (*Jambos jambos*) leaves at Río Piedras and on a blue gum (*Eucalyptus* sp.) at Naguabo. It has also been taken on *Anona muricata* and *Ficus nitida*, at Río Piedras.

Chrysomphalus aonidum (Linn.).

A serious enemy of citrus trees. In the publications of the Porto Rico Agricultural Experiment Station its occurrence on the island, fungi parasitic to it, and methods for its control have been discussed by Messrs. Earle (as *Aspidiotus ficus*) (4–459), Barrett (1–445), Henricksen (as *Chrysomphalus ficus*) (8–27) and Tower. (15–25, 26) (16–32) (17–24) (19–14, 15.) With the exception of the last reference, Mr. Tower mentions this scale as *Chrysomphalus ficus*.

It was collected by Mr. Busck in 1899 on *Terminalia catappa*, San Juan; on *Anona muricata*, San Juan; on oleander, Ponce; and

on *Musa,* Caguas. (2–93.) Mr. Carnes mentions having received it from Porto Rico. (3–398.) It has also been taken on *Ficus nitida* at Río Piedras and an sisal hemp (*Agava sisalana*) at Mayagüez.

Chrysomphalus aurantii (Mask.).

Mr. Busck took this species in 1899 "on *Anona muricata*, San Juan," and on the same host at Ponce. (2–93.) In 1904 M. Barrett reported it as an enemy of citrus stock, with the note, "rare but apparently spreading." (1–445.)

Chrysomphalus biformis (Ckll.).

On "maya" (*Bromelia pinguin*) at Mameyes; on *Agave sisalana* and "aguacate" at Río Piedras; on mango (*Mangifera indica*), Río Piedras, and on a cycad (*Cycas revoluta*), at Naguabo.

Chrysomphalus dictyospermi (Morg.).

On mango (*Mangifera indica*), at Río Piedras, and on a cycad (*Cycas revoluta*), at Naguabo.

Chrysomphalus personatus (Comst.).

Mr. Busck collected it "on plantain leaves, Caguas, January 11. On *Anona muricata*, San Juan, January 5. On banana leaves, Catana, February 21. On coconut palm, Mayagües, January 20; Caguas, January 11." (2–93.) On coconut palm (*Cocos nucifera*), Santurce; on rose apple or "pomarrosa" (*Jambos jambos*), Río Piedras; on mango (*Mangifera indica*), Santa Isabel; on leaves of a tree (*Ficus* sp.) and on "mamey" (*Mammea americana*), Mameyes; and on a blue gum (*Eucalyptus* sp.) at Naguabo.

Pseudischnaspis bowreyi (Ckll.).

Collected on asparagus fern at Mayagüez.

Pseudoparlatoria ostreata Ckll.

Collected on *Solanum seaforthianum* and *Acalypha* sp. at Mayagüez.

Lepidosaphes beckii (Newm.).

This species has been more often mentioned as a pest of citrus orchards than any other scale-insect. The following workers have discussed it in the bulletins and annual reports of the Porto Rico

Agricultural Experiment Station: Messrs. Earle (4–457, 458), Barrett (1–445), Henricksen (7–401, 402) (8–27) and Tower (15–26) (16–32, 33) (17–23, 24) (18–24, 25) (19–13, 15). In Messrs. Earle's and Barrett's articles and in the first article by Mr. Henricksen the species is given as *Mytilaspis citricola*. Mr. Carnes, of California, mentions having received *Lepidosaphes beckii* in shipments of material from Porto Rico, from which it was hoped to introduce scale-insect parasites into that State. (3–398.) Mr. Johnson records the fungi, *Myriangium duriaei* and *Sphaerostilbe coccophila*, from this scale. (11–28, 29.)

The species was taken on ornamental croton (*Codiaeum* sp.) at Río Piedras by the writer.

Lepidosaphes lasianthi (Green).

Collected on leaves of croton (*Croton humilis*) at Río Piedras.

Ischnaspis longirostris (Sign.).

Taken by Mr. Busck "on coconut palm, Caguas, January 11; Catania (probably misspelling for Cataño), January 12; Mayagüez, January 20; Arroyo, February 3." (2–93.) Taken by the writer at Naguabo on *Citharexylum fructicosm*. It has also been taken on *Ixora ferrea*, *Asparagus spengleri* and *Acrocomia media at* Río Piedras.

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HISTORY AND CAUSE OF THE RIND DISEASE OF SUGAR CANE.

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Introduction.

The rind disease of sugar cane has been one of the most widely discussed of all the cane diseases. It has been variously considered by some as being a harmless saprophyte and by others as having caused great damage in the cane fields. Chiefly owing to inaccurate and incomplete observations, literature on the subject is almost hopelessly confused as to the real nature of the fungus or the disease caused by it. That cane fields are still invaded by a serious disease of the rind which is always accompanied by a destruction of the tissues and a deterioration of the sugar content, render it important to ascertain the cause of the trouble. It is believed that a careful study of the literature in the light of numerous field and laboratory investigations will do much to clear up this subject. The writer has been studying the matter for the past three years and can come to no other conclusion than that the rind disease causes a great loss in many cane fields. When the nature of this disease is described and its history is shown, it is believed that this conclusion will be justified.

EXTERNAL APPEARANCE OF THE RIND DISEASE.

So confused is the literature on this subject that it will make the discussion clearer to state once for all that the rind disease is considered primarily a disease of the rind of the cane. Whatever effect there is upon other parts of the cane is considered secondary in ascertaining the cause of the trouble, although it may as a matter of fact be primary in the point of time in the life history of the fungus itself.

The external symptoms of the rind disease are primarily the appearance of numerous black pustules breaking through the rind of the cane. (See Plate I.) From these pustules oozes a coherent mass of spores which on exposure to the dry air hardens somewhat in the form of a stalk, varying in size and form from patelloid to subclavate or cylindrical, up to 1 or 2 mm. in length. Sometimes they appear merely as numerous tiny black threads breaking through the rind. When these black pustules appear, the tissues of the cane itself are already discolored and diseased. The relations of other symptoms of disease are complicated with the presence of other fungi and will be left to a fuller discussion further on. It will be noted that there are a few eruptions on the rind that are caused by different fungi. These will all be discussed in their proper place. The preceding brief diagnosis of rind disease will be used as a basis for discussing the history and full nature of the fungus and the disease caused by it.

THE AUTHOR'S INVESTIGATIONS OF THE RIND DISEASE.

FIELD NOTES IN PORTO RICO.

Conditions under which the rind fungus have been noted in Porto Rico are extremely variable. It has never been observed in fields of young green cane excepting in shoots injured or killed by some other fungus such as *Marasmius sacchari* or by such insects as the changa, the whitegrub, the root weevil, or the moth stalk-borer. In such cases it can hardly be considered more than a saprophyte.

In cane over six or eight months old this fungus can almost invariably be found on the leaf-sheaths of the cane, not universal on all stalks, nor on all varieties, but at least common in the cane

fields of Porto Rico. The fungus occurs not only at the base on the outside of the leaf-sheath, but occasionally near the joint of the leaf-sheath with the leaf-blade. On the leaf-sheaths, the fungus may hasten the drying of the leaf, but does not necessarily pass from the sheath into the stalk. Numerous canes have been observed up to maturity which had remained perfectly healthy so far as the stalk was concerned, but which had had the fungus on the leaf-sheaths for some months.

In contrast with the conditions found in green cane, in mature or almost mature cane considerable damage has been observed which appeared to be attributable to this fungus.

In Naguabo in 1912 a certain field of D625 presented an excellent growth. The planting was wide, *i. e.,* 7 feet between rows, but the stalks had developed well. Before the cane was considered quite ripe enough for cutting, it began to appear diseased, *i. e.*, black pustules appeared on the rind, the canes appeared water-soaked, and the tops died. In some cases moth borers were present, but with this exception there appeared no fungus in any quantity except the rind fungus *Melanconium sacchari.* In a few weeks' time this disease had spread over the field, not affecting all stalks, but some stalks in many stools. The loss in weight and sucrose before the cane could be cut was considerable.

Near Río Grande in 1912 was a field of a large yellow Demerara cane, probably D625 or D116, supposed by some to be identical canes. The growth of the cane at twelve months was excellent, consisting of an abundance of large stalks. It was generally known that this cane contained a comparatively small amount of sucrose especially on low wet soils such as in this case. It was suggested that possibly leaving the cane over for another season would produce a larger sugar content, therefore the canes were left for a period of twenty months. Long before this time had passed many of the stalks had become infected with the rind disease and become entirely rotted down, so that at the end of the period the field was almost an entire loss.

In the same vicinity in 1912 fields of the striped (*rayada*) and the native white cane (*Otaheite*), which were only twelve months old, behaved in the way.

This latter condition of cane twelve to fourteen months old rotting back with the rind fungus is not uncommon in Porto Rico. The moth stalk-borer is often associated with the fungus, but is no more common in diseased fields than in those not diseased. The conditions under which this disease occurs are not clear, but everything points

to a weakness in the cane due either to a weak soil or to drought or to excessive water. Apparently a variety of these conditions brings about much the same effect in cane.

Aside from the occurrence of the rind fungus in large mature canes, it is not uncommon to find it abundant in fields of cane that have been stunted through the presence of root disease, or some untoward soil condition. This is especially true in old ratoons that are running down. In Canóvanas in 1912 an entire field of cane failed to grow large and vigorous and before maturity almost the entire field was infected with this fungus and was a complete loss. In adjacent fields first crops have been obtained, but there, too, the ratoon crops have been lost in the same way.

In all cases in Porto Rico an infection with the rind fungus seems to be preceded by a weakening of the vitality of the cane through some other untoward condition. It happens, however, that these conditions cannot always be foreseen, and therefore the rind fungus must be considered a serious obstacle to the best results among the sugar planters. These various untoward conditions in themselves do not begin to have the effect that they do together with the rind fungus.

Cane may suffer from root disease, but does not rot out unless affected by the rind fungus also.

Cane may suffer from drought, but it does not deteriorate unless attacked by the rind fungus in addition.

Cane may suffer from floods, but that does not render it worthless as does a severe infection of the rind fungus.

Altogether the field investigations appear to demonstrate that *Melanconium sacchari* is capable of doing great damage in mature canes in Porto Rico.

INOCULATIONS WITH THE RIND FUNGUS.

Inoculations with pure cultures of the rind fungus have been made into green canes and into almost mature canes, but in no case was there any visible infection. In all these inoculations the cane was vigorous and the inoculating wounds were slight. This would tend to show that vigorous cane was not infected by this disease. No inoculating experiments have been made on weak canes.

FIELD INVESTIGATIONS IN SANTO DOMINGO.

Examination of the cane fields at La Romana, San Pedro de Macorís, and Santo Domingo city show the rind fungus to be common but not doing much damage. It is present only in canes which have

been seriously injured, *i. e.*, when the top has been cut off, and in these cases the infection has spread only to the first node, leaving the base of the cane perfectly sound.

INVESTIGATIONS IN THE SOUTHERN UNITED STATES.

Investigation here revealed quite the same conditions as in Santo Domingo; *i. e.*, no entire rotting of sound canes, but mere infection at the point of some serious injury and on the leaf-sheaths.

INVESTIGATIONS IN CUBA.

No extensive investigations have been made here by the writer of this paper, but stalks completely rotted by the rind fungus have been observed in the vicinity of Nipe Bay.

GREENHOUSE INVESTIGATIONS, WASHINGTON, D. C.

In the greenhouses in Washington, D. C., cane has been grown to a greater or less extent for the last seven or eight years. It has been common to find large stalks completely rotted out by this fungus. It is to be expected from our observations of the behavior of this organism that this would occur. Cane grown in the greenhouse is not as hardy as that grown out of doors; its roots are apt to be confined and the tops are subject to injury. Altogether the appearance of this disease in Washington corresponds well with the condition frequently found in Porto Rico and as casually observed in one place in Cuba, but not with its appearance as seen in Santo Domingo or the Southern United States.

It may thus be expected that there will be found a similar variation in the conditions in other countries which might to a large extent account for the variation in opinions regarding the importance of the rind fungus.

In the particular cases cited the possibility of confusing the case with infection by other fungi has been avoided by special search for such as *Colletotrichum falcatum*, so while there is no direct proof by inoculation that *Melanconium sacchari* causes the trouble under all conditions, there is the fairly satisfactory proof of it, arrived at by the process of elimination.

HISTORY AND IDENTITY OF THE RIND FUNGUS.

The first available description of a fungus breaking through the rind of the cane is that of *Strumella sacchari* by Cooke in Grevillea,

Vol. XIX, p. 45. He described this fungus from a specimen of sugar cane labeled Bailey 871 from Queensland, as follows:

"Pustules gregarious, erumpent, black, patelloid or subclavate, with a short stemlike base, or cylindrical multiform (½ mm. diam.), hyphae short, hyaline, simple; conidia cycindrically elliptical, continuous, pale fuscous, $10–12 \times 3$ microns." This description is purely one of the fungus and does not indicate the symptoms of the disease other than to say that the pustules are erumpent.

In 1878 Cooke published a description (8)[1] of one of Berkeley's species as follows:

Darluca Melaspora Berk. in litt. Pustulis prominulis, nigris, sporis oblongis binucleatis, cirrhis nigris. $.015 \times .115$ mm. From sugar cane in Australia.

In 1892 was published a new species by Ellis and Everhart in a paper by Cockerell (7). The name of the new fungus was *Trullula sacchari* and its description as follows:

Acervuli innate-erumpent or entirely black, coniglobose, ⅓ to ½ mm. diam., resembling perethecia. Conidia catenulate, forming at first a continuous, hyaline filament, 70–75 microns long, soon separating into oblong 2–3 nucleate, olivaceous conidia, $8–11 \times 2½–3$ microns, rounded at the ends, and closely resembling the sporidia of some *Hypoxylon*. The chains of conidia are densely crowded and simple. The erumpent acervuli blacken the surface of the culm with the discharged conidia, but some of the acervuli are entirely buried in the inner substance of the culm and are apparently never erumpent. Found in Jamaica, Barbados and Trinidad on sugar cane.

In 1893 Massee (26) described the black erumpent fungus on sugar cane as a Melanconium stage of *Trichosphaeria sacchari*. In a later paper (27) he gave the succession of these various stages as follows: from Melanconium stage to macro- and micro-conidial stages and thence to the ascigerous stage which he called *Trichosphaeria sacchari*. His work was based on material received from Trinidad and other English colonies.

Fawcett (14) in 1894 wrote that he found *Trichosphaeria sacchari* (the Melanconium stage) present in Jamaica, but he found other diseased material, which he sent to Kew and which was examined by Massee and pronounced *Colletotrichum falcatum*. Later he wrote (15) that he found *Trichosphaeria* (Melanconium stage) and that Massee considered it only a form of *Colletotrichum falcatum*.

In 1895 Saccardo (32) changed the name of Cooke's *Darluca melaspora* to *Coniothyrium melasporum*. In the same year Prillieux and Delacroix (31) studied material from Mauritius which showed the same black erumpent fungus on the cane as did *Darluca* and

[1] Figures in parenthesis refer to bibliography at the end of the article.

Melanconium and the others. They called the fungus *Coniothyrium melasporum* following Saccardo's name, as they believed their fungus to be identical with *Darluca melaspora*.

Thistleton-Dyer (34) published a summary of the cane diseases in Barbados, in which he reiterates the statement that at Kew *Colletotrichum falcatum* Went is considered merely as one phase in the life history of *Trichosphaeria sacchari*. It should be noted that it was not claimed that *Colletotrichum falcatum* was the same as any other stage of *Trichosphaeria*, for from its appearance there could be no confusion as to that. It was stated that *Colletotrichum* was considered a stage in the life history of *Trichosphaeria*. There was, however, no proof brought forward to support this claim and subsequently the idea was given up. At present they are believed by investigators in general to be distinct fungi.

Went (39) published in 1896, in an article on sugar-cane diseases, criticisms of Massee's work on *Trichosphaeria*, together with the statement that Massee's macro- and micro-spores of *Trichosphaeria* were remarkably like the macro- and micro-spores of Went's *Thielaviopsis ethaceticus*. Went's opinion was strengthened by examination of West Indian material. He also found *Melanconium* spores in Java and from pure cultures obtained both the *Melanconium* spores and macrospores. Thistleton-Dyer (l. c.) believed Went's *Melanconium* was not really the *Melanconium sacchari* of the West Indies.

Massee (l. c.) had claimed that *Thielariopsis* was the same as his macro- and micro-spores of *Trichosphaeria*, thus agreeing on this point with Went except that the latter did not connect them with the perfect stage of *Trichosphaeria*.

Prillieux and Delacroix (l. c.) agreed with Massee in considering *Thielaviopsis ethaceticus* to represent the macro- and micro-spore condition of the *Melanconium* fungus which they called *Coniothyrium*.

Finally in the history of the rind disease Howard issues a paper (19) in which he shows that *Colletotrichum falcatum* and *Melanconium* are not stages of the same fungus, but he claims that the former is the cause of the rind disease and not the latter. As Howard has made a most unfortunate confusion between cause and effect here, it will be necessary to discuss the matter more fully.

In preceding pages of this paper there was given a description of the fungus causing the rind disease and producing those symptoms commonly recognized as belonging to the rind disease, *i. e.*, numerous eruptions of the rind from which issue black masses of spores. As to whether this disease causes further destruction of the

tissues or as to whether there are other fungi that cause the destruction of the rind or of other tissues, that matter has not been discussed. The description of *Colletotrichum falcatum* as given by Went is as follows:

> Setis nunc seriatis, nunc in psuedo-conceptaculum, congregatis, cuspidatis, 100–200 x 4, conidiis falcatis, 25 x 4, hyalinis, ad basim setulorum, basidiis ovoideis, 20 x 8, hyalinis vel fuscis, suffultis.

Went found the fungus on living cane, but most of the reports definitely state that while the vegetative hyphae are common on living cane, fruiting bodies are very rare except on dead cane. Such being the case, it is not clear how *Colletotrichum falcatum* produces any eruptions on the rind. As to whether it does cause a serious disease of the cane is entirely a different matter.

From the foregoing descriptions it will be seen that five different names have been given to black erumpent fungi on sugar cane, *Strumella sacchari*, *Darluca melaspora*, *Trullula sacchari*, *Melanconium sacchari* and *Coniothyrium melasporum*, the last being admittedly the same as Darluca. It will be desirable to ascertain if all these names may apply to one and the same fungus. It must first be stated that the common fungus producing these black eruptions on cane throughout the West Indies, Hawaii, Mauritius, Natal, Australia, and other places appears to be one and the same and to be correctly classed as *Melanconium sacchari*. More rarely are found similar forms which might be mistaken for *Melanconium*. It will be desirable to review the descriptions of the fungi already mentioned in order to judge whether they may be considered to be *Melanconium* or distinct fungi.

1. *Strumella sacchari.*—Said by Thistleton-Dyer (35) to be the same as *Melanconium sacchari*. *Strumella* belongs in the *Tuberculariaceae*, quite a distinct group from that containing *Melanconium*. There is nothing in the description to indicate that the fungus is a true *Strumella* or that it cannot go in *Melanconium*. In fact, investigators seem agreed that these two names really belong to one and the same fungus.

2. *Darluca melaspora.*—Massee (28) states that this species is founded on material sent to Berkeley in 1878 from Porto Rico and not from Australia as stated by Cooke. Furthermore he states that the material itself shows the fungus to be a *Diplodia* and not a *Darluca*. It would seem that Massee's examination ought to settle the question, but it is not clear how Cooke's description of *Darluca melaspora* can apply to a *Diplodia*. Rather does it resemble *Melanconium* with the one-celled binucleate spores, 12 x 5 microns, and

black threads. To what the "cirrhis nigris" or "black threads" applies is not evident whether to pustules or to spores, but in neither case it would apply to a *Diplodia*. It would seem more likely that there were both forms in the material or that the material had been mislabeled. It would appear that Cooke's *Darluca melaspora* is really *Melanconium sacchari.*

3. *Trullula sacchari.*—This fungus has been said by Massee (27) to be similar to the macroconidial stage of *Trichosphaeria sacchari.* However, Massee evidently did not note that while his macroconidia measure 18–20 x 12 microns, the spores of *Trullula* measure 8–11 x 2½–3 microns, too great a difference to permit of their being considered as identical. It is possible that *Trullula sacchari* corresponds to the microconidia of *Trichosphaeria sacchari,* especially as the general description answers fairly well for it. Thus "conidia catenulate, forming at first a continuous, hyaline filament, 70–75 microns long, soon separating into oblong 2–3 nucleate, olivaceous conidia," answers fairly well for either fungus. However, "Acervuli innate erumpent or entirely black, conic-globose, ⅓–½ mm. dia. resembling perethecia" does not apply to the microconidia stage of *Trichosphaeria* but to the Melanconium stage. To no other known fungi does this description apply, and as the material is reported from at least three islands it is believed that the description was meant for one of the common cane fungi, *i. e.*, *Melanconium*, and possibly mixed with the microconidial stage of *Trichosphaeria.*

4. *Melanconium sacchari* described by Massee is placed in its proper genus. Massee, however, believed that he found also other stages of the same fungus. The perfect stage he called *Trichosphaeria sacchari.* This work will be discussed fully further on. It is sufficient to state here that *Melanconium sacchari* is the generally accepted name for the common erumpent black fungus found on the rind of sugar cane in many countries.

5. *Coniothyrium sacchari.*—This is Saccardo's name for *Darluca melaspora*, which has already been shown to be in all probability identical with *Melanconium sacchari.* Massee (l. c.) states that Prilleux and Delacroix in their paper (l. c.) have fallen into an error in considering *Melanconium* the same as *Coniothyrium.* They described material from Mauritius as *Coniothyrium sacchari* and illustrated their description with a plate. The illustration leaves little doubt that the material was *Melanconium*, and the description answers fully as well for *Darluca.* Apparently these are all one and the same fungus.

In summing up it is seen that—

Strumella sacchari is generally admitted to be identical with *Melanconium sacchari.*

Darluca melaspora is said to be a *Diplodia*, but really appears to be *Melanconium sacchari.*

Trullula sacchari is said to be identical with the macroconidial stage of *Trichosphaeria* but appears to be the same as *Melanconium sacchari.*

Melanconium sacchari is the generally accepted and proper name for the rind fungus of sugar cane.

Coniothyrium melasporum, same as *Darluca melaspora,* is probably *Melanconium sacchari.*

LIFE HISTORY OF THE FUNGUS.

In the foregoing paragraphs there has been given brief mention of various references to the so-called rind fungus as it has been understood by various investigators. In the main *Melanconium sacchari* and its various possible forms are considered the cause of the disease and will be treated as such.

Melanconium sacchari, the ordinary form of the rind disease, consists of dark septate hyphae running within the stalk of the cane. Immediately below the epidermis the hyphae often forms a layer of pseudo tissue from which arise the short conidiophores bearing the terminal conidia. These are produced in large numbers and if their formation is close to the surface of the epidermis, the mass breaks through and oozes out either forming a black conical heap or a long slender thread entirely made up of the spores. The variation in this formation apparently depends upon the rapidity of the formation of the spore mass, which in turn depends upon the moisture conditions in the atmosphere. These spores germinate and are supposed to grow into the cane and after increasing vegetatively to repeat the spore formation. The method of entrance through the rind of the cane is not positively known. It may be through the stomata, or through such wounds as those caused by the stalk-weevil, the moth borer or the ambrosia beetle, or there is the bare possibility that the hyphae can penetrate the cells of the epidermis itself.

There has been much discussion as to whether this fungus does not produce more than one kind of spore—that is to say, have more than one stage of growth. It is common for some fungi to have various stages of growth, and it is of the utmost importance to know them all in order to work out control measures for the disease. As

already mentioned the first description of *Strumella sacchari,* which has been identified with *Melanconium sacchari,* describes only the Melanconium form. Massee was the first to claim that he had found more than one stage, *i. e.,* a macroconidial and a microconidial stage in addition to the Melanconium stage. In his paper on the subject he attempted to prove the genetic connection between the forms. Massee placed four conidia (Melanconium [?] spores) in each of three flasks containing equal quantities of sugar-cane solution, and then placed the cultures for incubation in a temperature of about 75° F. At the end of five days the liquid in each of the flanks presented an opalescent appearance which examination showed to be due to very delicate, much branched hyphae. Examination of the contents of a second flask after eight days' growth showed numerous filaments of mycelium measuring up to 8 microns in diameter and full of brilliant, fine-grained, homogeneous protoplasm. These thick hyphae originated as lateral branches from the delicate hyphae first produced by the conidia.

A third flask after twelve days' growth assumed a dark olive color and the entire surface of the mycelium at the level of the solution presented an appearance of an olive-colored, dense, velvety mass. The velvety appearance proved to be due to the presence of closely packed, erect, dark olive conidiophores growing out into the air, each bearing at its apex a single chain of reddish-brown conidia—called by Massee microconidia. The dark olive color of the mass of mycelium immersed in the fluid was found to be due to immense numbers of large conidia arranged in chains and springing from the tips of the thick hyphae previously described. These latter forms Massee called macroconidia.

It must be observed that Massee's method of procedure is not sufficiently described in detail to demonstrate clearly the origin of these various spores. He starts with four of the Melanconium spores placed in each of three flasks, but nothing is indicated to show that there might not have been some contamination. The first two flasks were treated after examination so that their contents were killed. As a result he found the microspore and the macrospores only in the third flask.

After the above experiment in which he is assumed to have produced from Melanconium spores two other forms in flasks, Massee took small portions of cane containing hyphae of Melanconium and placed them in a nutrient solution. The characters which distinguish Melanconium hyphae from others are not given, nor is it stated that there were no other hyphae present, nor is the operation stated

to have been done under sterile conditions. After twelve days the nutrient solution was crowded with mycelium bearing both forms of conidia, that is, the micro- and the macrospores. Further Massee took internal portions of diseased cane near the apex and placed them in a nutrient solution, care being taken to prevent the accidental introduction of other fungi. There resulted rapid growth of the hyphae and eventual formation of macroconidia.

An inoculation experiment was next carried out by introducing Melanconium conidia upon the base of an old leaf-sheath of cane six feet high. After twenty days Melanconium spores were produced. At the same time a small portion of diseased cane containing hyphae of the Melanconium stage were introduced into a slit made into a cane stalk. Mature fruit burst out of the cane after twenty-two days. Eight days later this cane was split open and it was found that at the joint where inoculation was performed by wounding the cane, the mycelium had produced the large macroconidia in the decaying tissue. No macroconidia were present at the point where infection took place through a dead-leaf base.

An inoculation experiment was made by placing the macroconidia on the basal part of the upper surface of a very young leaf; in five days the infected area became a deep red, and in fourteen days a dense pile of conidiophores appeared on the surface bearing microconidia. Internal macroconidia were not found. Nothing was said by Massee about the presence of Melanconium spores.

Another inoculation was made by placing macroconidia on the broken surface of a lateral shoot which had been broken off close to the stem. In fourteen days microconidia were formed, but no macroconidia, and no mention is made of Melanconium spores.

Two more experiments showed practically the same results, the macroconidia, however, being found in one case.

An inoculation made with microconidia produced both the micro- and macroconidia but no Melanconium spores.

Neither Massee's flask cultures nor his inoculation experiments can be taken as any proof that the Melanconium spores are in any way connected with either the micro- or macrospore forms.

Massee found two mature perithecia on a much decayed portion of a cane received from Barbados; they sprang from a point that had previously borne a crop of microconidia and were surrounded by old collapsed conidiophores, the conidia having disappeared. Massee says "although the evidence in favor of a genetic connection between the perithecia found on the cane and the microconidia with which they were associated, was strong, yet it could not be accepted

as conclusive; and it was not until similar perithecia were accidentally discovered on the surface of the material contained in one of the flask cultures, that this supposition was proved to be correct." The flask referred to was one filled with a mass of hyphae produced from a macroconidium. The submerged portion was black from a copious development of maeroconidia, while the surface was covered with a dense pile of conidiophores bearing microconidia. This flask was accidentally broken and out of curiosity Massee examined a portion of the contents bearing microconidia. Two young perithecia were found which were almost colorless and without spores but bearing the long characteristic bristle-like, septate hyphae as did the mature perithecia found on the decayed cane. Two examples of the initial stage of a perithecium were found. The culture was placed under favorable conditions for the further growth of the perithecia, but unfortunately soon became covered with Penicillium and other growth, and gave no further results. However, from these results Massee concluded that he had the perfect stage of the fungus which he named *Trichosphaeria sacchari;* and as has already been stated he concluded this stage to be derived from the macrospore stage, which in turn arose from the Melanconium stage. The microspore formation was considered somewhat in the light of a variation of the macrospore formation, and like it to be derived from the Melanconium spores. It has already been shown that the genetic connection between the Melanconium stage and the macrospore and the microspore stages has not been demonstrated by Massee. It is equally clear that the finding of perithecia amidst macro- and microconidia on diseased cane and finding immature forms of some perithecia (possibly the same) on a culture of macro- and microconidia which are not demonstrated pure cultures does not prove or any more in the slightest degree suggest a gentic connection between the macro- and the microspores and these perithecia. Thus Massee has constructed the life history of the Melanconium fungus largely out of assumption.

It has been claimed in reference already quoted that *Melanconium* has a fourth stage in the life history, that of *Colletotrichum falcatum.* No work, however, was published to prove this assumption.

Went (39) in 1896 took up the matter of the relationship of the *Melanonium* with the macro- and microconidia. These two latter forms appeared to him to be identical with what he called *Thielaviopsis ethaceticus* and especially for that reason he wished to determine if there was any relationship between the various forms. Unfortunately the fungus with which Went worked does not correspond

to the West Indian *Melanconium*, so that the results cannot be taken as for or against Massee's claims.

In 1900 Howard (20) published a rather elaborate paper on his researches on this subject. He had already stated in another paper (21) that he had infected unsterilized pieces of cane with Melanconium spores and five days afterwards macro- and microconidia had developed. He found later, however, that a repetition of the experiment gave the macro- and the microspore forms as frequently on control canes as on inoculated canes. He thus concluded that the genetic connection between the various forms was *not* demonstrated. Howard further made many inoculation experiments both with the Melanconium form and with the macro-spores; he cultivated the macroconidial stages for over two years; and he had flask cultures under observation for 18 months, but in no case did he find Melanconium spores give rise to macroconidia or vice versa. He states that several thousand rotten canes were examined, but in no case did he find peritheecia corresponding to Massee's *Trichosphaeria sacchari*.

From these various discussions it will be seen that no form other than the one originally described under the name of *Strumella* by Cooke has been proven for the *Melanconium*. There is the minor possible exception of chlamydospores found by Went with his questionable *Melanconium sacchari* but corroborated by Howard in flask cultures. So far as has been shown they have little bearing on the reproduction of the fungus as it actually occurs in the fields. Thus, so far as is known to-day, the life history of *Melanconium sacchari* is very simple, consisting only of the vegetative part producing stylospores, which in turn reproduce the plant.

ASSOCIATED FUNGI.

As has already been seen several fungi have been found associated with *Melanconium sacchari*, some of them so closely that they have been assumed to be stages of the same fungus.

Thielaviopsis ethaceticus.—The micro- and macrospores of *Melanconium* as described by Massee were believed to be identical with the spores of *Thielaviopsis ethaceticus* by Went. Howard was also of the same opinion. *Thielaviopsis* is not commonly found in standing cane, but is common in cut cane that has been left standing about or particularly in seed in the soil. *Melanconium* is characteristically found in standing cane. However, when affected seed is used the fruiting bodies of *Melanconium* may be found on seed in the soil.

Colletotrichum falcatum.—This was originally described by Went in Java as the cause of the red-rot or red smut. It is supposed to

gain entrance through borer holes or wounds in the cane, but does not usually fruit until the cane has dried out considerably. The fruiting bodies appear in velvety black patches on the dry part of the cane. Under a lens small black bristles are found to be abundant, and from among these arise the single-celled, colorless, more or less falcate spores. There is no evidence of pustule formation nor of any formation to mistake the *Colletotrichum* for the *Melanconium.*

Diplodia cacaoicola.—This fungus has been found on cane in India by Butler (3), in Barbados by Howard (22), and in Porto Rico by the author. A fungus was sent to Kew in 1878 from Porto Rico and was described in manuscript as *Darluca melaspora.* This was referred to by Cooke in Nuovo Gionale Bot., Vol. X, p. 26, 1878, who according to Massee (l. c.) incorrectly gave the locality as Australia. Saccardo changed the name to *Coniothyrium melasporum*, quoting Cooke's diagnosis incorrectly in Syll. Fung., Vol. III, No. 1799. Prilleux and Delacroix (31) in their paper on sugar-cane diseases have, according to Massee, wrongly considered *Melanconium sacchari* as synonymous with *Coniothyrium.* Examination of Berkeley's type specimen by Massee revealed the fact that it was a *Diplodia.* As already shown, however, on previous pages, Prilleux and Delacroix's description answers to that of *Melanconium* and not to *Diplodia.* When Massee examined the material he must either have seen another fungus or examined the wrong specimen. A fungus answering to the description of *Diplodia cacaoicola* occurs at present in Porto Rico on cane. This fungus forms pycnidia, which break through the rind in conical projections, thus resembling to some extent the eruptions of Melanconium. This fungus, however, has not been reported as common in any country, so that there is little danger of confusing it with *Melanconium.*

Cytospora sacchari.—This fungus has been reported by Butler (3), who states that it might be confused with *Melanconium.* It forms similar black eruptions on the surface of the rind. It has so far been reported only from India and from Porto Rico.

Melanconium saccharinum.—This fungus was originally reported from Java, but is common in Porto Rico, Santo Domingo and the Southern United States. Under certain conditions it might be mistaken for *M. sacchari.* This latter, besides occurring on the stalk, is abundant on the leaf sheaths and on that part of the leaf blades immediately adjoining the sheath proper. In these locations it seldom sends out the long threads, but usually appears as conical eruptions. Much the same appearance is presented by *M. saccharinum* and in the same part of the leaf. The two fungi may be present

at the same time. So far as is known *M. saccharinum* does not occur on the cane stalks, with the exception of the flowering stalk, and is not as yet known to cause serious damage.

Gnomonia iliau.—This fungus occurs in Hawaii and in Louisiana. The perfect or Gnomonia stage might at a casual glance be mistaken for *Melanconium sacchari*, but the necks of the perithecia are slender and hard and do not spread out as do the black spore masses of the rind fungus. The imperfect stage of *Gnomonia iliau* is called *Melanconium iliau* and to the writer does not present satisfactory means of identification to the naked eye, so closely does it resemble *M. sacchari*. Under a lens, or more especially under a compound microscope, the differences are readily apparent.

GEOGRAPHICAL DISTRIBUTION OF THE DISEASE.

United States.—The rind fungus (*Melanconium sacchari*) was reported by Dr. Stubbs in the Louisiana Planter for May 21, 1910. Edgerton (11) reported it as occurring only on seed cane. H. R. Fulton, formerly of the Louisiana Agricultural Experiment Station, sent to Washington specimens of *Melanconium sacchari* on cane. This was sent from New Orleans on October 19, 1907. About 1905 Dr. Erwin F. Smith was growing cane in the greenhouses in Washington, D. C., for studies on the gumming disease. On much of this cane *Melanconium sacchari* appeared. In the summers of 1911 and 1913 more cane was grown in other greenhouses in Washington, and on this cane appeared much of this disease. Further than these notes there are no records of the occurrence of this disease in the States, with the exception of the author's notes. These notes report its occurrence in Florida, Georgia, Louisiana, and Texas.

Cuba.—The fungus was reported as common on dead canes, leaf-sheaths and dead leaves that had been kept in a moist place and also as frequent on dead or injured parts of living canes, by Horne and Cooke (10). The writer has also seen this disease on standing cane at Nipe Bay, Cuba.

Jamaica.—As already mentioned, *Trullula sacchari* E&E identical with *Melanconium sacchari* was sent from Westmoreland County, Jamaica, and reported on by Cockerell (7) in 1891–93. Fawcett (15) in 1895 reported the rind disease due to *Melanconium sacchari* to be common on certain estates, especially in cane tops affected by the moth-borer.

Santo Domingo.—The author reported the rind fungus common in most of the cane districts of this Island in 1913.

Porto Rico.—Cane diseased by *Melanconium sacchari* was sent from Porto Rico to the United States Department of Agriculture in Washington in 1906 (?) and was identified by the writer. Tower (36) reported the fungus present especially on the south side of the Island. Fawcett (16) the following year reported it, stating that it was very common on the east end of the Island. In the report of the writer (23) for 1910–1911 the fungus is said to be prevalent all over the Island.

Barbados.—Bovell (2) reported in 1895 in regard to the rind fungus that "in many instances so badly has the disease attacked the canes that instead of an acre giving from two to three hogsheads of sugar it will require many acres to give one hogshead."

South (33) in 1909–1910 reported this fungus as always present on dead canes which are dry.

British Guiana.—Harrison and Jenman (18) stated that until early in 1894 the canes in British Guiana appeared to be quite free from fungoid disease, although the fungus *Trichosphaeria sacchari* could be found in greater or less abundance on dead canes and on the dead parts of dying canes in probably every field in the colony, but in February, 1894, they noticed that several varieties of seedlings were affected with rind fungus. Specimens of this fungus on cane were received from both Demerara and Essequibo.

Other English Colonies, in the West Indies.—Prof. Harrison (l. c.) visited Trinidad, St. Vincent, Barbados, Antigua, Grenada, and Carriacou and found the rind fungus present in all of them. South (l. c.) reported as follows:

St. Vincent.—The rind fungus occurred to a considerable extent, but chiefly in fields of the Bourbon variety of cane.

Antigua.—The fungus was not prevalent, but cases were somewhat more frequent than formerly. It was often noticed in fields badly attacked by root disease.

St. Kitts.—It was not observed to any extent.

Nevis.—It was observed on some estates. Seedling cane B147 was always more subject to attacks than any other variety.

Argentine.—Engler and Prantl (13) record *Melanconium sacchari* Massee on cane in Argentine.

Mauritius.—Prillieux and Delacroix (31) record the fungus in Mauritius. In an article entitled *La Maladie de la Canne* in *La Sucrerie Indigenie et Coloniale*, pp. 361–363, Vol. VII, 2d semester, 1894, is correspondence between Thistle-Dyer, of Kew, and M. W. Scott, of Mauritius, and discussion of the rind disease caused by

Melanconium sacchari. The Melanconium form was found to be very abundant. Massee records it from Mauritius in 1894.

British India.—Melanconium sacchari is stated by Butler (3) to be rare in British India. It is also reported from India by Massee (29). Barber (1) also records the fungus from India.

Tonquin.—The fungus was reported in this part of Indo-China by Prilleux and Delacroix (l. c.).

Java.—Went (38) describes its appearance in Java. His description in the Annals of Botany (39) is such, however, to lead one to suspect that he did not have the West Indian *Melanconium sacchari.* Thistleton-Dyer (35), in discussing the subject, thinks he had a very different fungus. Went describes black spherical conidia as being connected with the *Melanconium* with which he was working, and no one else has as yet published a description of such a form. He mentions chlamydospores, so that it cannot be certain just what Went had, although these were also found by Howard (20).

Natal.—Fuller (17) reported in this colony a fungus on sugar cane supposed by him to be *Strumella sacchari,* which, as we have seen, is identical with *Melanconium sacchari.*

Queensland.—The first description of *Strumella sacchari* was by Cooke (9) from a specimen received from Queensland. Tryon (37) also also records the occurrence of the rind disease in this country.

New South Wales.—Cobb (4) reported *Strumella sacchari* as occurring there.

Hawaii.—Perkins (30) in 1904 stated that "nearly a year ago, * * * an unusal outbreak of some parasitic leaf-fungi was noticed, and this was shortly followed by a similar spread of fungous diseases affecting other parts of the cane. It must not be supposed that these fungi are new to this country; they have been known to us for at least some years sporadically, but are now epidemic. The present epidemic is clearly due to the abundance of the leaf-hopper.

"At present by far the most widespread and injurious of these diseases is the so-called Rind Disease. * * *. On examining the stripped stem of young cane, I find that the fungus has already attacked this severely. * * * Whole fields of cane are simply saturated with the spores of the fungus."

Cobb (5) in 1906 stated that he had "noted the presence of rind disease in sufficient quantity to call for remedial action." Lewton-Brain (24) described the rind disease and the loss caused by it in 1907. Cobb (6), writing again in 1909, said that in many fields, especially ratoon fields of Lahaina cane, it was common to find the sheaths of the "*lalas*" (shoots from the top of the cane) attacked

by rind disease. "I have seen fields of this kind in which nearly every *lala* showed the spores of rind disease issuing from the sheaths of its lowest leaves, and when the higher leaves were pulled away it was evident that these, too, were attacked and in the first stages of the disease."

PARASITISM OF THE FUNGUS.

The fact that *Melanconium sacchari* has attracted such widespread notice would lead one to assume that it was without question a parasite. Still careful workers cannot accept the prevalence alone of an organism to indicate its parasitism. Though it may not in this case be an active parasite it is necessary at least to know its degree of parasitism before recommending methods of treatment.

A misleading idea given in many articles on fungous diseases is that the very presence of an organism to the apparent exclusion of others, or the preponderance of one organism over another indicates that it is the cause of whatever disease may be in the host plant. Thus the presence of *Melanconium* has been assumed by many to indicate that it was the cause of the diseased condition of whatever cane it might be found in.

Massee (27) was the first to publish the results of inoculation experiments with this fungus. His experiments were as follows:

Experiment I.—A sugar cane, 6 feet high and 1½ inch in diameter at the base, was inoculated by placing Melanconium conidia upon the base of an old leaf sheath, the leaf having fallen away. After twenty days the Melanconium fruit was fully developed, the long black filaments of conidia oozing out through minute cracks in the cuticle about half an inch above the node, and from the point of inoculation. At the same time as this experiment was made a small portion of diseased cane containing hyphae of the Melanconium stage was introduced into a slit made in the cane; this experiment resulted in the appearance of mature fruit bursting out from the cane after twenty-two days. The cane was cut down ten days after the last-mentioned experiment, and on being split open it was found that at the point where the inoculation was performed by wounding the cane the mycelium had produced the large macroconidia in the decaying tissue.

Experiment II.—Melanconium conidia were placed on moistened patches of young living leaves of sugar cane, some of the patches being first carefully washed to remove the bloom on the surface of the leaf, others not being so treated. After twelve days there were no signs of infection on the unbroken surfaces of young leaves and

stems, hence Massee concluded that while *Melanconium* was a parasite it was only a wound parasite. In his own words he demonstrated conclusively that the fungus called *Trichosphaeria sacchari* (the Melanconium stage) can effect an entrance into healthy tissue quite independently of the agency of "shot-borer" or "moth-borer."

"Although a true parasite, in the sense of destroying perfectly healthy tissues, the fungus almost invariably commences as a saprophyte."

Besides Massee, Went made inoculation experiments to demonstrate the parasitism of this fungus. As before remarked, however, we cannot be certain that the *Melanconium* with which he worked is identical with that of the West Indies. With the fungus with which he was dealing he made inoculations into slits made into sound canes; the mycelium developed in the cells surrounding the slits, but in no case (9 experiments) did it attack the healthy tissue of the cane. Later he sterilized pieces of sugar cane by keeping them in a flame for some time; he then divided them longitudinally with a sterilized knife and placed them in a sterilized glass box. On the cut surface he placed some of his Melanconium spores, but out of ten experiments only three finally showed pycnidia, and this was on dying cane. Thus Went does not consider *Melanconium*, or whatever fungus he was working with, to be parasitic.

So far as publications show Howard has been the only other one to test the parasitism of the rind fungus. He published a report (21) of his experiments in 1900, in which he split open healthy unsterilized canes and inoculated them with Melanconium spores, and with mycelium developed from a pure culture. Five days afterwards both micro- and macroconidia developed. Later, however, Howard (20) decided that these micro- and macroconidia had no genetic connection with the Melanconium spores, as they appeared as frequently on control canes as on the inoculated ones. In his early experiments he had concluded that *Melanconium* was parasitic as some infection had resulted. As the infection did not spread, however, more than three inches above and below in three months' time, and as the canes showed none of the typical appearance of the disease he concluded to repeat the experiment. The results are set forth in the last publication cited.

Experiment I.—On November 27 eighteen healthy Bourbon canes were selected, of which six were used as controls and twelve for inoculation at wounds, six with Melanconium spores from a pure culture and six with similar spores and food material. The places where the wounds were made were cleaned with alcohol and flamed with a spirit

lamp. The holes were cut with a sterile knife, and after being inoculated were bound up with sterilized tape which had been soaked in parafin. The control canes were treated in a similar manner, but in this case no spores were introduced. On Decmeber 28 these canes were examined. In no instance had the mycelium spread to any extent, except immediately above and below the wound where it had reached the nearest nodes. The affected tissues were a bright red, but the cane exhibited no traces of the rind disease. The controls showed no infection, although the cells around the wound were bright red and the bundles cut through showed gumming in the large vessels.

Experiment II.—On December 10 four healthy White Transparent canes were inoculated with Melanconium spores from a pure culture at wounds made with a sterile knife as before. Four other canes from the same stool were used as controls. Thirty days afterwards the canes were examined. In all cases the tissues were brownish red above and below the wounds, but no difference was evident between the inoculated canes and the controls in this respect. On examining the inoculated canes it was found that the mycelium of the fungus had in all cases spread in the tissues immediately above and below the wounds as far as the nearest nodes, but it could not be traced beyond the vertical column of tissue containing the wound and bounded by the nodes above and below this aperture.

Experiment III.—On December 19 four healthy White Transparent canes were doubly inoculated—at wounds in an upper and a lower internode—with actively growing mycelium of the fungus from pure cultures. Four other canes were used as controls. On January 22 the results were almost identical with those obtained above.

Experiment IV.—The same experiment was made using only spores from a pure culture instead of the mycelium. The same results were obtained.

Howard concluded as a result of his studies that *Melanconium* cannot be considered as the cause of the "rind" disease. He appears to have shown that *Melanconium* is not an active parasite, but it is not clear that he has demonstrated this fungus to be only a saprophyte. In fact his inoculations rather point to *Melanconium* being a wound parasite. Howard appears to be assuming that the rind disease is caused by an active parasite, for the proof of which he presents no facts whatever.

CAUSE OF THE RIND DISEASE.

In discussing the cause of the rind disease it will be well to review briefly the symptoms of this trouble first. As mentioned in

an early part of this paper the rind fungus is one causing numerous tiny black eruptions from the rind or epidermis of the cane stalk. From first to last there has been only one fungus found in these typical eruptions. It was first called *Strumella sacchari* and later *Melanconium sacchari,* the name under which the fungus is known at present. As to the secondary symptoms it is very difficult to judge for the reason that usually insects, other fungi or unsatisfactory growth conditions are present to complicate the matter. In cane affected with the rind disease the leaves begin to wither and dry up. Often a rotten top is found. Frequently there is a reddening of the stem. Now as to which of these symptoms are connected with the rind disease no one has as yet attempted to make an analysis. That being the case we have only the eruptions of the rind for a certain characteristic of this disease. From these only *Melanconium* has been isolated, absolutely no other fungus. How then can we conceive of some other fungus as the cause of these symptoms? It is manifestly impossible. That Howard failed to obtain successful inoculations is not to the point. There has been no work done to show that *Melanconium sacchari* was not the cause of the eruptions of the rind of the cane.

Now Howard has approached the subject from an entirely different point of view. He has selected certain symptoms of disease in the plant, isolated fungi from the diseased parts, inoculated pure cultures of the fungus into healthy tissues and obtained the same symptoms of disease, and has then concluded that the fungus he is dealing with is the cause of the rind disease, disregarding the fact that neither the symptoms nor the fungus have much to do with the rind and have nothing whatever to do with the eruptions on the rind. The symptoms of the rind disease as he gave them are the drying of the leaves, which commences at the margins of the older ones and gradually spreads to the center of the bunch in from four to six weeks. As soon as this drying of the leaves is well marked, the stem of the cane shows a brown discoloration in one or more places, after which the rind shrivels up and the discoloration rapidly extends in all directions. On splitting such canes the tissues are seen to be of a general reddish color, in which darker red areas can be seen. Very freqaently these darker regions contain definite white centers elliptical in vertical section. He states that the appearance is exactly like that figured by Went for the Red Smut due to *Colletotrichum falcatum.* Howard isolated this fungus and made successful inoculations and thus concluded that the rind disease was due to *Colletotrichum falcatum.*

It is unfortunate, to say the least, that the matter of the cause of the rind disease should be further involved by confusing the symptoms. Howard is here dealing with an entirely different fungus and entirely different symptoms from those which characterize the rind disease.

As has been shown neither Howard nor Massee nor any other worker succeeded in getting good pure culture inoculations of *Melanconium sacchari*. On the other hand, no one has found any other fungus than *Melanconium sacchari* associated with the typical conditions of the disease, *i. e.*, the eruptions of the rind. Until more is done, therefore, to prove the contrary, *Melanconium sacchari* should be considered as the cause of the rind disease.

NATURAL INFECTION OF STALK, LEAVES AND CUTTINGS.

Whatever question there may be about the active parasitism of the rind fungus, there can be no question as to the actual occurrence of the fungus on the cane in the field. The following is in part a repetition of what has gone before, but taken altogether it will serve to summarize the conditions.

OCCURRENCE ON THE STALKS.

Melanconium sacchari commonly occurs on green cane stalks at such points of injury as those caused by the weevil borer, near the base of the stalk. These injuries are not sufficient to kill the stalk and it remains green until infected by the rind fungus, and even then the infection progresses only according to the vigor of the cane. The fungus occurs at similar points of injury caused by the moth stalk-borer which may occur any where along the stalk, perhaps more commonly near the top. The moth borer or some bud moth often gets into the top of the cane and kills the heart. This injury is usually succeeded by an infection of the rind fungus which progresses downward. Occasionally the top is rotted and a Melanconium infection is present without any sign of insect injury. The extent of all this damage depends largely upon the vigor of the cane as discussed elsewhere.

OCCURRENCE ON LEAVES.

A point that apparently has not been considered of great importance is the occurrence of this fungus at the base of leaf-sheaths and occasionally near the joint of the sheath and blade. This occurrence is very common in cane over 8 or 10 months old. It has not been proven to be the same as the stalk fungus, but it cannot be

separated from it morphologically. It would seem to the writer that this point is of considerable value, for it may be assumed that so long as the fungus is present in the field anywhere, either on the leaf-sheaths or elsewhere, that there is a possibility of some damage whenever the right conditions for it occur. There is some variation in the different varieties of cane so far as apparent susceptibility is concerned, and observations have been made on over 50 varieties. However, the occurrence of the fungus does not seem to be constant so that up to the present it is not possible to state definitely that certain varieties are more immune than others. In general the softer varieties such as T77 are more commonly infected on the leaves than such as D116.

OCCURRENCE ON CANE CUTTINGS.

Very commonly cuttings that have failed to germinate have been dug up and found infected with this fungus, apparently killed by it.

On one occasion several sacks of cuttings were kept for a period of five weeks. When they had been cut they were supposed to be free from disease, but examination at the end of the five weeks showed that out of 156 cuttings, 135 had the rind fungus, and of these 135, 71 had the rind fungus and no other.

LOSS DUE TO THE RIND FUNGUS.

In a disease of this kind it is impossible to state definitely the amount of loss caused. The injury is usually associated with that due to other causes, and it is impossible to consider them apart. One may say that a certain field of cane is entirely destroyed by the rind fungus, whereas the rind fungus might not have infected the cane in the first place if it had not suffered from root disease, drought, moth-borer injury or any one of several factors. It is also just as true that one may say that the same field was entirely destroyed by any one of these factors, where as a matter of fact the loss would not have been half so great without the rind fungus. In general terms I would state that the loss due directly to the rind fungus is often very heavy, involving a partial or complete loss of hundreds of acres of cane in some seasons.

TREATMENT OF THE DISEASE.

It is sometimes unsafe to make recommendations for the treatment of a certain disease when the cause or nature of the disease is not well understood. If the recommendations are restricted to general

improved methods of cultivating the cane or of handling it, however, they may be valuable. Such has usually been the type of advice given by various investigators when working on this disease.

In 1895 there was published in the Kew Bulletin an article on sugar-cane disease in Barbados and extracts were included from the report of the commissioners appointed by the Governor of Barbados to inquire into the pests and diseases of the cane. This commission made the following recommendations:

> That all plants be soaked in Queensland solution[1] before planting.
>
> That whenever deemed possible by the inspector the practice of spreading trash around young canes be given up; and that whenever it be resorted to, only trash from a field which had been inspected and declared healthy or as healthy as possible be employed.
>
> That rotten canes on all fields diseased with rind disease should be burnt on the field, or crushed and burned as mentioned below.
>
> That rotten canes on all fields be regularly burned during the crop. Juicy canes could be first crushed and the megass burned, the juice being boiled.
>
> That the trash used as litter be taken from fields which are healthy or as healthy as can be got.
>
> That each estate put such an area under the so-called hardy varieties of cane plants as will suffice to replant the whole of the estate in those varieties if necessary.
>
> That the cane fields be periodically inspected, with a view to cutting out the canes infected with borer or fungus, which canes should be bagged upon the spot and taken away, crushed and burned.

Fawcett, writing in the same year (1895) in the Bulletin of the Botanical Department of Jamaica, adds to the foregoing recommendations the following:

> Only healthy tops of strong canes should be used as seed canes.
>
> To avoid any chance of the fungus existing unnoticed in the tops, they might be steeped in a solution of sulphate of iron (one ounce powdered in three gallons of water) for a few hours, especially if they are pierced by the borers.

Unfortunately no report of experiments is available to show the value of this latter suggestion. The idea of the sulphate of iron is purely as a disinfectant, which is well accomplished by the use of Bordeaux mixture. Moreover, it should be noted that the mycelium of the rind disease may be within the stalk as well as at the surface, and if there is any of the mycelium within, soaking in any mixture long enough to kill the fungus growth within will also injure the cane. Dipping seed in sterilizing mixtures is purely for the purpose of destroying external fungi and providing a protective covering to prevent the entrance of fungi.

[1] Queensland solution equals one pint of carbolic acid to 100 gallons of water.

ALLIED FUNGI.

This subject has already been discussed so far as other alleged stages of this fungus are concerned. The claim that *Trichosphaeria sacchari* is the perfect stage of *Melanconium sacchari* has been shown to be without sufficient proof. The so-called microconidia and macroconidia of *Melanconium* have been shown to be in all probability the same as *Thielaviopsis ethaceticus,* apparently an entirely different fungus.

Other species of *Melanconium* have been described, among which are the following:

Melanconium saccharinum Penz et Sacc. in Malphigia, 1901, p. 238; Ic. Fung. Jav. t. LXV. f. 3.—Acervulis hypophyllis, gregariis, longitrosum seriatis oblongis, 1 mm. long., 0.5 lat., nigris, epidermide hysteriodes-rimosa velatis; conidiis majusculis globoso-compressis e fronte 24 microns latis, e latere 14 microne cs., nigrantibus, levibus, hyphulis filiformibus tenerrimis, hyalinis suffultis. Sacchari officinarum prope Buitenzorg, in insula Java.—affine *M. bambusino* et *M. hysterino,* sed satis diversum videtur. (from Saccardo.)

Melanconium iliau Lyon described in a Study of Iliau by H. L. Lyon in Hawaiian Sugar Planters' Record and by Edgerton. This fungus is so described as to be in all grosser appearances exactly similar to *Melanconium sacchari.* Its method of fruiting is exactly the same, but the spores are very different. They are large and filled with spherical granules, measuring 7–10 x 15–28 mu.

SUMMARY.

1. The symptoms of the rind disease are the eruptions on the rind of the cane from which protrude black masses of spores, together with a drying up of the leaves.

2. The disease has been studied for the last twenty years at least in various parts of the world.

3. The fungus causing the rind disease has only one known spore form in its life history.

4. The rind fungus occurs in the Southern United States, all through the West Indies and Demerara; in Natal, Mauritius, British India, Java (?), Australia, and Hawaii.

5. The fungus is what is known as a wound parasite, *i. e.*, capable of infecting cane only through wounds, or cane that is in an otherwise unhealthy condition. It may be classed as an active parasite on certain weak or soft canes such as Bourbon and D116.

6. The rind disease is caused by *Melanconium sacchari*, one of the fungi imperfecti.

7. Treatment of the disease is restricted to the use of hardy varieties, to adopting such methods as will reduce the moth borer, and to grinding the cane before it is overripe.

8. *Melanconium saccharinum* and *M. iliau* have also been described on cane, but are not to be considered as causes of the rind disease.

9. The rind disease is common in Porto Rico.

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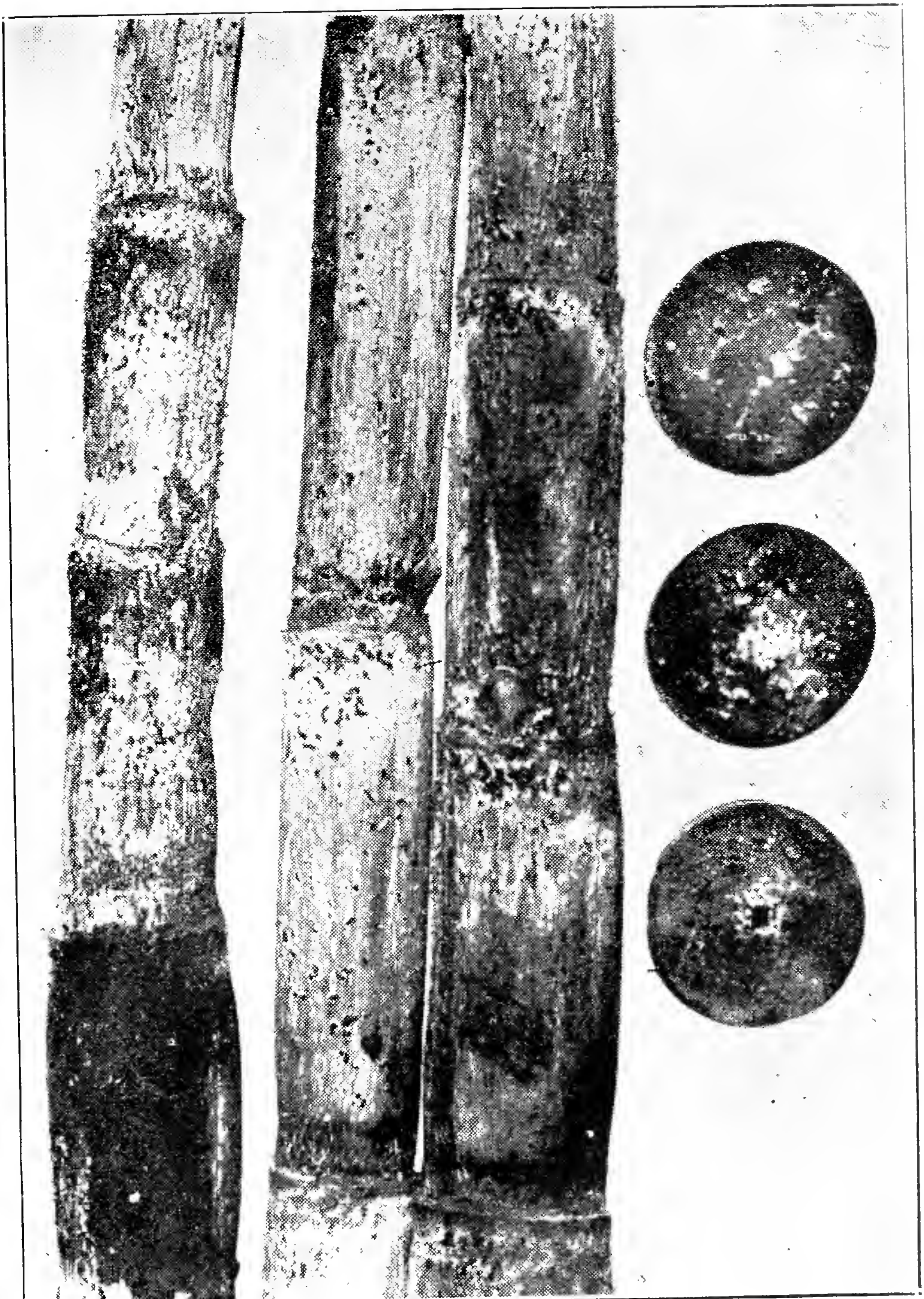

PLATE I.

Stalks of cane severely attacked by rind disease, showing the characteristic black fruiting pustules.

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A change in title of this publication has been made necessary by the change in the Government of Porto Rico, which has placed the Insular Experiment Station and other functions of the Board of Commissioners of Agriculture under the direction of the Commissioner of Agriculture and Labor.

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THE WHITE-GRUBS INJURING SUGAR CANE IN PORTO RICO.

I. LIFE-CYCLES OF THE MAY-BEETLES OR MELOLONTHIDS.

By Eugene G. Smyth,[1] Acting Entomologist, Insular Experiment Station.

The larvæ of all injurious Scarabaeid beetles are known popularly as white-grubs, and those occurring in Porto Rico are injurious either as grub or as adult to the sugar-cane plant, particularly in the drier sections of the Island. An economical way of controlling these grubs is much desired, and it has been with the object of finding some ultimate method of control that the intensive studies of the life-histories of the species have been made.

Up to the present date ten distinct species of white-grubs have been segregated and studied. Of these, four belong to the genus *Phyllophaga* (better known as *Lachnosterna*) and one to the genus *Phytalus* in the tribe *Melolonthini*, while the other five belong to three genera in the tribe *Dynastini*, which includes the large rhinoceros beetles. The present paper deals only with grubs of the first tribe, known as May-beetles, and is an accumulation of data compiled from observations and life-history studies made by the author during the past four years. The work was conducted at the South Coast Laboratory, located near Guánica Centrale, which is in the heart of the district suffering most from the attack of white-grubs.

The life-cycles and habits of the five species of Dynastids will be given in another paper, to follow this.

The White-Grub Problem.

Two facts, that sugar is grown over very extensive areas in Porto Rico, under conditions that are ideal for the development and rapid

[1] Especial credit is due Mr. D. L. Van Dine, the first entomologist of the Experiment Station of the Porto Rico Sugar Growers' Association, and his successor, Mr. Thos. H. Jones, for the initial energy given to the study of the white-grub problem in Porto Rico by these gentlemen. The writer wishes to acknowledge the keen interest in the progress of this work and the cooperation given by Dr. L. O. Howard and Dr. W. D. Hunter, of the United States Bureau of Entomology, and by Dr. S. A. Forbes, of the Illinois State University, and their very efficient aid to those who have been detailed to collect parasites in the United States. Credit is also due Dr. Robert D. Glasgow, of Illinois University, for his patience in examining the large series of May-beetles that have been sent him from the Island and in pointing out characters by which they may be separated. The writer wishes to thank Mr. John J. Davis, of West Lafayette, Indiana, for an excellent series of North American species of *Phyllophaga* mounted with genitalia exserted.

multiplication of beetle pests of this sort, and that it is grown continuously year after year on the same ground, without any rotation of crops, render the control of these insects a very serious and very difficult problem. Prior to 1913, the year that the present studies were inaugurated, a considerable amount of experimentation had been made by different parties toward controlling the white-grubs in cane fields, (1) by putting baits, poisons, or fumigants into the soil, (2) by spreading various deterrants on the soil near plants to prevent laying of eggs, (3) by flooding the land with water, or (4) by killing the adult beetles by means of poison sprays applied to the foliage. The results of many of these experiments were negative; and such of them as gave promising results proved inexpedient because of the high cost of materials or of application.

It became increasingly apparent that no hope of a solution of the problem could come from an application of direct methods of control such as these, but that real benefit to the cane-growing industry could come only through the employment of broadly outlined cultural methods of control, based upon an accurate knowledge of the insects' life-histories, or perhaps through the introduction of insect or fungus parasites to prey upon the white-grubs.

Life-history and close field studies of the several species were instituted in May, 1913, and have been continued to the present date. The object constantly in mind has been to determine accurately the length of life-cycles; the time and conditions of oviposition of the eggs; the time of emergence, sexual habits, feeding habits, and habits of flight of the adults; and the inter-relation of these habits and the factors which tend to hasten or retard the time of emergence of the beetles or to affect the amount of damage.

A preliminary report by the author appeared in the Annual Report of this Station for the year 1913–14 (23)[1] and some additional data in the Report for 1914–15 (24). Much of this data is included in the present paper, together with tabulations and graphic charts showing life-cycles, and illustrations showing injury, the early stages, adults and adult parts, parasites, etc., from original photographs.

Methods of control of white-grubs, and results of the introduction of parasites, will be discussed at length in a later number of this publication, when certain experiments and tabulations now in progress will have been completed. Detailed studies of the larval (or grub) and pupal stages, now being made, by which it is hoped

[1] Reference is made by number to "Literature cited," pp. 88–89.

that these stages of the different species may be as easily separated as are at present the adults, will also be presented in another article.

The desire at present is to present the life-cycles of the Porto Rican Melolonthids; to facilitate the separation of the adults of the species, where heretofore they have been hopelessly confused; and to present certain facts in regard to their insect, fungus and bacterial enemies that have come to light in the course of experiments.

What White-Grubs Are.

All beetles pass through a metamorphosis consisting of four stages, egg, larva, pupa, and adult, two of which, egg and pupa, are resting stages and the other two, larva and adult, active stages. The growth of the insect is attained during the larval stage; which means that during this stage the most food is consumed, and hence the most damage committed. It is with the larval stage of the May-beetles and "hard backs," known locally as "caculos," that we are concerned. During this period they gain the name of white-grubs (or "gusanos blancos") through their white color, and their habit of grubbing in the soil.

As the term is used in its broadest sense, white-grubs are considered as including the larvæ of all the injurious Lamellicorn beetles of the family *Scarabaeidae* (3). The word is often used in the United States in a more restricted sense, as referring to the grubs or larvæ of the May-beetles, since these in the States far outnumber all other white-grubs combined (4).

White-grubs may be known from larvæ of other beetles by the following characteristics: (1) subterranean habits, living entirely in tunnels in soil or decaying vegetable matter, and moving about very little; (2) by having the body bent roundly toward the ventral side, so that the ends nearly meet, hence poorly adapted to movement above ground; and (3) by their bodies being thick, soft, and usually glossy white or yellowish with sparse hairs, with a brown, chitinous head and strong mandibles adapted for chewing roots and soil, and with six well-developed legs not used for walking.

White-Grubs Injurious in Other Regions.

Larvæ of Scarabaeid beetles are practically universal in their occurrence as pests, being everywhere known as white-grubs. They are particularly destructive, and often multiply in alarming numbers, in parts of the world where cane is grown, due to conditions which greatly favor their development in such localities. Besides Porto

Rico, they have attained great prominence as pests of cane in the islands of Mauritius and Java, and on the continent of Australia.

White-grubs of the genus *Phyllophaga* are best known as pests to crops in the United States, being widely distributed and having a great many species. As many as forty-two species have been recorded from the single State of Illinois, most of them injurious (8). Damage of the grubs to grass lands, lawns, corn, potatoes, and other crops is often very extensive (4), and the adults have been known to defoliate the timber over whole counties (5, p. 270).

A beetle known as *Ligyrus rugiceps* is a bad pest of cane in Louisiana, having the habit of boring into the stalks at the surface of the ground. In irrigated sections of the Southwest the large green "June bug," *Allorhina mutabilis*, whose larva is a white-grub, does very great damage to fruit.

In Europe members of the genus *Melolontha*, which is closely related to *Phyllophaga*, have been known for over a century as pests, the grubs of one species (*Melolontha melolontha*) frequently causing so much damage to cultivated crops as to necessitate the gathering of the grubs from the fields by hand. In Russia great damage is caused by both grub and adult of a beetle known as *Anisoplia austriaca* (13).

In Australia several white-grubs of the same tribe (known as *Melolonthini*), notably of the genus *Lepidiota*, are the cause of great injury to cane. As much as a shilling a pint has been paid for the grubs from cane fields by the sugar centrals of Queensland. The principal pest is known as *Lepidiota albohirta* (11).

Five species of white-grub, representing five different genera, are injurious to sugar cane in Java; namely, *Holotrichia helleri*, *Adoretus compressus*, *Apogonia destructor*, *Leucopholis rorida*, and *Lepidiota stigma* (10; 14). Trap lights for the adults are used at night.

Various species of the genera *Anomala* and *Adoretus* are destructive in the Hawaiian Islands, in Japan, and in British East Africa.

In the cane-growing sections of India the roots of the plant are subject to attack by white-grubs that are the larvæ of a beetle known as *Serica assamensis*. Other species of white-grubs have also been reported as injurious in India.

Among island possessions, next to Porto Rico, perhaps the most acute injury to cane by white-grubs has been committed by a species known as *Phytalus smithi* in the islands of Barbados and Mauritius. The adult of this beetle differs but slightly from species of the genus *Phyllophaga*. The species is becoming particularly bad in Mauritius, because of its having been introduced there from Barbados without

the wasp parasite, *Tiphia parallela* (2), which in the latter island tends to hold it in control. To illustrate its abundance in Mauritius (where for a while it threatened to paralize the sugar-cane industry), in a period of nine months, from August, 1911, to April, 1912, a total of twenty-seven and one-half millions of grubs, pupae, and adults (mostly adults) were collected from the sugar-cane fields over an area scarcely three miles square surrounding the Botanic Garden (6).

In the West Indies, aside from Barbados and Porto Rico, cane is known to be injured by a species of *Phyllophaga* in Antigua (26) and by grubs of *Phyllophaga patruelis* in St. Kitts (22). The adults of *P. patens* are said to be very destructive to cacao foliage in St. Vincent (19). A bulletin of the American Museum (15) lists 24 species of *Phyllophaga* and 2 of *Phytalus* from the West Indies, 13 of which are credited to Cuba and 4 to Haiti, but none to Porto Rico.

In British Guiana a beetle known as the "small black hard back," *Dyscinetus bidentatus*, which is the adult of a white-grub, is considered a bad enemy of cane, and a related species, *Ligyrus ebenus*, is occasionally injurious (16). Like the *Ligyrus rugiceps* of Louisiana, it is the adult stage in which damage is done by these two beetles. *Dyscinetus* sometimes attacks young cane shoots in such numbers as to kill them back as fast as they germinate.

Life-History Work on White-Grubs Done Elsewhere.

Because of their subterranean habits, white-grubs are among the most difficult of insects to rear to maturity and to gain any definite knowledge of their changes, or molts. Outside of Europe, prior to 1916, very few species had been reared to maturity and their life-cycles determined. As late as 1913, a bulletin of the U. S. Department of Agriculture (4), in discussion of the genus *Lachnosterna* (*Phyllophaga*), stated: "There is only one published record, involving a single species, in which an individual belonging to this genus has been reared from egg to adult." Since that date, however, considerable breeding work has been done in Indiana by Mr. J. J. Davis, of the U. S. Bureau of Entomology, to whom credit is due for having successfully reared to maturity from the egg eighteen species of the genus, definitely establishing the length of life-cycle of each (5).

In Australia similar difficulties have confronted investigators in this group of insects. In a bulletin of the Bureau of Experiment Stations of Queensland published in 1914 (9), it is stated: "At first rearing was depended upon to give us evidence of the entire period of development, but we have not as yet succeeded in rearing a single

specimen through its stages, but may succeed in doing so by the time the next beetle season arrives."

Outside of Europe, and the work done by Mr. Davis in Indiana, the nearest approach to accuracy in establishing the length of life-cycle of a beetle of the group *Melolonthides* is the work done in Mauritius on *Phytalus smithi* by Mr. d'Emmerez *de Charmoy* (6). He determined the maximum and minimum number of days required for each stage of the life-cycle, but did not determine the length of separate instars of the grub.

So far as known to the writer, nothing has been published heretofore on the larvae of *Phyllophaga* or related genera which establishes accurately the lengths of instars of the grub.

LIFE-CYCLES OF WHITE-GRUBS.

It has been known for a number of years that the common cockchafer of Europe, *Melolontha melolontha*, whose grub is the worst white-grub pest of that continent, required a period of three years to pass its life-cycle in the latitude of France and southern Germany, and four years in the latitude of northern Germany.

In the United States it has been taken for granted that certain common species of *Phyllophaga*, such as *P. fusca* and *P. fraterna*, because of the regular periodicity of their appearance in numbers every three years, require that length of time to pass the life-cycle (7). Certain other species in the States, appearing regularly at intervals of two years, were supposed to require that length of time to undergo the change from egg to adult (33). Very recently Mr. Davis has definitely ascertained that out of eighteen species of *Phyllophaga* reared from egg to adult in the latitude of central Indiana eleven of them have an invariable three-year life-cycle, one (*Phyllophaga tristis*) has an invariable two-year life-cycle, three have a life-cycle varying from two to three years, and two others a cycle varying from three to four years (5).

The establishment of the fact that all four Porto Rican species of *Phyllophaga*, as well as the single species of *Phytalus*, require but a year or somewhat less to undergo the life changes, will be somewhat of a surprise to students of this group of insects. Yet it is what should be expected in a tropical or sub-tropical climate.

These facts are paralleled, in a measure, by those established by Mr. De Charmoy with regard to the life-history of *Phytalus smithi* in Mauritius—with the difference that he found the life-cycle of that species to occupy somewhat over a year (6).

Enemies of White-Grubs.

The natural enemies of white-grubs fall into three classes, namely, animals (including birds and lizards), insects (including mites and worms), and plants (fungus and bacterial). A noted French naturalist has said of the common European white-grub that "efficacious animal parasites of the insect are unknown" (29).

Fortunately, in Porto Rico, all three groups of parasites are present; yet as all of these are insufficient to keep white-grubs in check, it is necessary—when other means of control fail—to supplant these, or rather assist them, by the introduction of parasites not already occurring here.

ANIMAL AND BIRD ENEMIES OF GRUBS IN PORTO RICO.

There are in Porto Rico no small mammals known to prey extensively upon white-grubs or May-beetles as do skunks in the United States. Perhaps field mice and rats eat occasional specimens, but as an agency of control they can be of no great economic importance.

An attempt was made in 1913 by one of the sugar centrals of the Island to introduce and acclimate the European hedgehog, quite a number of which were brought over from Germany for the purpose. Most unfortunately, they were liberated in a hot and arid part of the Island, so different from their native humid and shady habitat that they did not survive. In confinement they ate May-beetles voraciously when fed them, but were not seen to burrow deep enough into the soil to reach the grubs; and it is a question if they would have proved of real economic importance as a control measure had they become successfully established.

In Porto Rico insect-feeding lizards are extremely abundant. The majority of these, which belong to the genus *Anolis*, are too small to devour the larger May-beetles. In addition they are diurnal in habit and live entirely above ground, usually upon plant foliage or trees. There is one large ground lizard, however, called "siguana" (*Ameiva exul*), which is largely burrowing in habit and which, it is believed, feeds to some extent upon white-grubs and May-beetles. It inhabits the sandier soils, and by one close observer has been often seen devouring changas, or mole-crickets. Certainly, white-grubs would be far easier prey for it than the active changas; and it is altogether probable that they do constitute a part of its diet.

Of birds, there are at least three species on the Island that are important enemies of the white-grubs and May-beetles, and a fourth that is worthy of mention. These are, in the order of their importance

as enemies of grubs: (1) the Porto Rican blackbird or "mosambique," *Holoquiscalus brachypterus*; (2) the bare-legged owl or "múcaro," *Gymnasio nudipes nudipes*; (3) the little blue heron or "garza azul," *Florida caerulea caerulescens*; and (4) the mangrove cuckoo or "pájaro bobo," *Coccyzus minor nesiotes*. In Bulletin No. 15 of this Station, entitled "Birds of Porto Rico," by Alex Wetmore, the results are given of an examination of the stomach contents of these four species of birds as follows (the figures being the per cent. of white-grub and May-beetle remains to entire contents of all stomachs examined): blackbird, 1.61 per cent.; bare-legged owl, 24.4 per cent.; little blue heron, 1 per cent.; and mangrove cuckoo, .05 per cent. Of twenty-three blackbird stomachs collected largely in cane fields under cultivation, the proportion of white-grub and May-beetle remains to total contents was 9.47 per cent. Certainly, after a day of activity of the birds behind the plows in cane fields, the proportion would be much higher than this.

Another bird, known as the "ani," or "Juda bird," has been often spoken of as eating white-grubs; but the bulletin above referred to does not give account of the finding of any white-grub or May-beetle remains in stomachs of this species. And, moreover, common as the bird is about cane fields, it is a rather shy species and is seldom seen following the plows.

The blackbird, or "mosanbique," is placed as the most important bird enemy of white-grubs because of its great abundance in those parts of the Island where the white-grubs are most injurious, namely, in the arid coast districts. It is a very common sight to observe considerable flocks of these birds following the plows and picking up grubs when fields cleared of cane are being broken up. Figure 1, of Plate VI, is from a photograph taken by the author at Santa Rita, near Guánica Centrale, during the winter plowing season. By actual observation and count, it was shown that over 90 per cent of the grubs exposed to light by the plows are picked up by these birds, so that the employment of peons to follow the plows and pick grubs is quite unnecessary in that district. When it is considered that a bird is able to consume more than the equivalent of its own weight of food in twenty-four hours, and that blackbirds during the plowing season of five to six months subsist almost wholly upon grubs, one may appreciate the vast numbers of grubs that they consume.

INSECT ENEMIES OF GRUBS OCCURRING ON THE ISLAND.

Among the insect enemies of the May-beetle larvae and related white-grubs there are at least nine species known to occur on the

Island, all native, which makes an unusually good representation as compared with other islands of the West Indies. These fall into three groups, six of them being Hymenopterous (all Scoliid), two of them Dipterous (both Tachinid), and one Coleopterous (Elaterid). Those of the first and last groups attack only the grubs, while the Diptera attack only the adults.

We may add to these four others, all of which have been observed attacking the grubs (or eggs) under laboratory conditions only. One of them is a white nematode, not exceeding 5 or 6 mm. in length, which on several occasions gave trouble by destroying the eggs in experimental jars. More troublesome than the nematodes was a species of minute, globular white mite (*Tyroglyphus* sp. ?), which attacked all stages of the beetles, from egg to adult, and was the cause of a high per cent of mortality in experimental jars and boxes.

Of minor importance were a Staphylinid beetle larva (species undetermined) and a wireworm, the young of an Elaterid beetle (*Monocrepidius* sp.), both of which were observed to feed upon May-beetle eggs in experimental jars. Both were introduced with earth enriched with manure, and it is not believed they would ever cause mortality of eggs under natural conditions in the field.

The following list will serve as a guide to the known white-grub parasites of the Island. The more important of them will be discussed later under the species they attack.

No.	FAMILY	SPECIES [1]	HABITAT	ABUNDANCE
1	*Scoliidæ*	*Elis sexcincta* Fab.	General.	Common
2	"	" *xanthonotus* Roh.	Northern	"
3	"	*Campsomeris dorsata* Fab.	General.	Abundant
4	"	" *trifasciata* Fab.	Northern	Common
5	"	" *pyrura* Roh.	Southern	Rare
6	"	*Scolia atrata* Fab.	Western.	"
7	*Tachinidæ*	*Cryptomeigenia aurifacies* Wal.	Northern and Western	Abundant
8	"	*Eutrixoides jonesii* Wal.	Western.	Rare
9	*Elateridæ*	*Pyrophorus luminosus* Ill.	Northern and Western	Abundant

[1] The determinations of the wasps (except *Scolia atrata* Fab., which was determined by the Am. Mus. Nat. Hist.) in this list were made by S. A. Rohwer, of the flies by W. R. Walton, and of the beetle by E. A. Schwarz.

The only one of these parasites which has been found hyperparasitized is *Campsomeris dorsata* Feb., a dead adult of which was found at Santa Rita containing a single Dipterous puparium, about 5 mm. long, from which issued, on June 18, 1913, ten small Chalcidids, which have not been determined.

Outside of Porto Rico, *Elis sexcincta* Fab. (?) was collected by the writer in great abundance on Mona Island in December, 1913, where it occurred on the leaves of corn infested with *Peregrinus maidis*. *Campsomeris pyrura* Rob. was taken commonly at Higueral, Santo Domingo, in February, 1914, and a few also were taken on Mona Island.

EFFICIENCY OF WHITE-GRUB PARASITES IN PORTO RICO.

Our knowledge of the white-grub parasites of the Island is at present very limited, and much is yet to be done in the working out of hosts and life-histories of the various species.

Of the nine species of white-grub parasites listed above, there is direct evidence of only one of them destroying the grubs of *Phyllophaga*. This is the Elaterid beetle, *Pyrophorus luminosus* Ill., larvæ of which have been fed upon *Phyllophaga* grubs for long periods in confinement in the insectary. Field observations of this wireworm preying upon white-grubs are still too few to make any definite statement as to its value in white-grub control. The beetle is extremely abundant in the spring and summer on the north and west sides of the Island; if true that it destroys white-grubs under outdoor conditions, its presence may perhaps account in part for the lesser injury from grubs in the sections where it abounds.

Some of our earlier notes (for the year 1911) credit *Campsomeris dorsata* Fab. with being a parasite of *Phyllophaga* grubs (30, p. 36). But in all cases the grub determinations were doubtful. It seems probable that the parasitized grubs in question, if not of *Dyscinetus*, which closely resembles *Phyllophaga* in the larval stage, were of *Ligyrus tumulosus* Burm., whose grub is abundantly parasitized at all seasons by *Campsomeris*.

It may develop, with additional observation, that the two species of *Elis* occurring here one or both parasitize grubs of *Phyllophaga* in restricted localities. Yet the strange fact remains that of thousands of *Phyllophaga* grubs collected in cane fields, and examined by the writer, not one has ever been found parasitized by a Scoliid egg or larva.

THE TACHINID PARASITES.

Our present knowledge of white-grub conditions leads to a belief that the most important and active agency in the control of white-grubs in Porto Rico is the work of the two Tachinid flies, *Cryptomeigenia aurifacies* Wal. (Pl. VII, fig. 7) and *Eutrixoides jonesii* Wal., upon the adults. Like the *Pyrophorus* beetle, these flies seem

confined to the more humid sections of the north and west coasts—which may further explain why white-grubs are less abundant and destructive in these sections than on the dry south coast, where there are few or no Tachinid parasites or *Pyrophorus* beetles. An account of the discovery of these two flies will be found on page 37 of the Second Report of the Board of Commissioners of Agriculture of Porto Rico (30). The adult and pupal case of *Cryptomeigenia aurifacies* Wal., which is the commoner species, are shown on Plate VII, figure 7.

INTRODUCTION OF PARASITES.

From many observations and estimates, it is evident that the mortality to white-grubs from parasites in Porto Rico is very low, and that the native parasites are quite insufficient to cope with these pests, which continue to increase wherever cane is grown. The only hope in relieving this condition has seemed to be in the introduction of other white-grub and May-beetle parasites from abroad. Among the first efforts made in the artificial control of the white-grubs of the Island, therefore, were attempts to introduce foreign parasites, which it was hoped would establish themselves successfully on the new host grubs (27, p. 52).

The logical field for securing white-grub and May-beetle parasites was the United States, not alone because they are better known there than elsewhere in the western hemisphere, but also because, in a large territory like the American continent, parasites have wider distribution, and necessary conditions for collection that cannot be encountered in one locality may be met in another. For convenience of handling, collection of grub parasites is usually made of the cocoon stage from the soil, and is therefore done during plowing time. Plowing time in the States shifts from south to north with the advance of the season, thus permitting the collecting to extend over a much longer period than would be possible in limited areas.

Parasite introduction was initiated in 1911 by Mr. D. L. Van Dine, then entomologist of the Porto Rico Sugar Producers' Experiment Statiton. His reports of the early progress of the work will be found in the First and Second Reports of the Board of Commissioners of Agriculture (29; 30).

An entomological collaborator was employed by the Board for the purpose of collecting living white-grub parasites, or parasite cocoons, in the States and shipping them to Porto Rico in living condition. The position was first held by Mr. C. E. Hood, who began work on June 16, 1911, and later by Mr. Geo. N. Wolcott. The work

was continued up to October, 1914, the majority of the parasites having been collected in the State of Illinois. During this time a total of about 2,500 parasites (including adults, larvæ and pupæ) were received from these workers, and of these a total of about 1,000 parasites were liberated. The great majority of these were wasps belonging to the genus Tiphia. (See Plate VII, fig. 8.) In addition to the parasites sent here, a number of cocoons of Elis were sent to Mr. O. H. Swezey in Hawaii for use against the white-grubs of those islands.

Following is a list of the better known *Phyllophaga* parasites occurring in North America. From these it was necessary for the parasite collectors to choose those species which could be most easily collected in numbers and sent to the Island.

NORTH AMERICAN PARASITES OF *Phyllophaga* LARVÆ.

1. *Tiphia inornata* Say.—A black Scoliid wasp of wide distribution in the States, and possibly infesting the grubs of several species of May-beetles (7, 21, 35). It is the commonest and best-known American parasite of white-grubs. There are several related species, for the most part feebly differentiated from it. (In Europe a species called *Tiphia femorata* attacks white-grubs of several *Melolonthids* (32); another, *Tiphia parallela*, attacks *Phytalus smithi in* Barbados (18), and *Dyscinetus bidentatus* in Demarara) (16).

2. *Elis (Myzine) 5-cincta* Fab.—A common Scoliid white-grub parasite occurring in the Central States, but more local in distribution than the *Tiphia*. There are other species of this genus found in restricted localities.

3. *Ophion bifoveolatum*.—An Ichneumonid wasp that parasitizes white-grubs, but is far less common in most localities than the Scoliid wasps.

4. *Pelecinus polyturator*.—A Proctotrypoid wasp, the female of which has a very long body, as if for penetrating the soil for oviposition. It has been reared by Professor Forbes from May-beetle larvæ and, being very abundant in timber land in some districts of the Middle West, may be a more important enemy of white-grubs than is generally known.

5. *Sparnopolius fulvus* Wied.—A small Bombyliid fly parasitic upon white-grubs, of only secondary importance, however.

6. *Promachus vertebratus* Say.—A large Asilid fly, larvæ of which are predacious upon white-grubs. The species is said by Mr. J. J. Davis (5) to be a prominent grub enemy in certain parts of Wisconsin. A nearly related species in the East is *Promachus fitchii* O. S.

7. *Microphthalma disjuncta* Wied. (*Megaprosopis michiganensis*).—A large Tachinid fly parasite of white-grubs, said to be common in the Central Western States. Mr. Vassiliev reports the same Tachinid as parasitizing the grubs of *Anisoplia austriaca*, and three other species, in southern Russia (32). Another closely related species in the States is *Microphthalma pruinosa*, also of wide distribution.

8. *Mochlosoma* (*Prosena*) *lacertosa* V. d. W.—This large Dexiid fly was reported by J. H. T. Townsend as issuing in great numbers from the puparia in the soil in pasture lands near Colonia García, Chihuahua, northern Mexico, and he was certain they were parasitizing white-grub (29). The determination of the fly was made by Doctor Coquillet. (A related species, *Prosena siberita*, attacks grubs of *Adoretes compressus* in Java.) (10).

9. *Ptilodexia* (*Estheria*) *tibialis* Desv.—Another Dexiid fly, which Davis mentions as parasitizing white-grubs in Texas (5, p. 271).

10. *Pyrophorus* sp.—An Elaterid beetle, very abundant in southern Texas, the larvæ of which are predacious upon a common white-grub of that section.

Parasites of the Adults.

11. *Pyrgota undata* Wied.—An Ortalid fly, the commonest and most efficient parasite of adult May-beetles in the Central States, and also generally distributed. Another species, more local in habitat, is *Pyrgota valida* Har. These are nocturnal in habits, as are also the following *Tachinid* flies.

12. *Cryptomeigenia theutis* Walk.—A Tachinid fly quite commonly infesting the bodies of adult May-beetles in some sections of the United States. The only other representative of the genus known to the writer is the common Porto Rican species, *Cryptomeigenia aurifacies* Wal.

13. *Eutrixa exile* Coq. (*Nemoraea masuria* Walk.)—Another Tachinid fly parasitizing May-beetles. It has habits like the preceding, infesting the beetle body.

14. *Biomyia lachnosternae*.—This Tachinid, identified by Mr. Walton, is the one referred to by Dr. Forbes as *Viviana* sp. in Bul. 116 of the Illinois Agr. Exp. Station, according to Mr. J. J. Davis (5). It was reared from the adult of *Phyllophaga crenulata*.

15. *Sarcophaga helicis* Towns.—This Sarcophagid fly was reared from adults of *Phyllophaga arcuata* collected at Washington, D. C.

INTRODUCTION OF FUNGUS ENEMIES.

Simultaneous with the introduction of insect parasites of white-grubs into Porto Rico, Mr. Van Dine initiated an attempt to introduce certain entomogenous fungi that are known to attack white-grubs and beetles related to the May-beetles in other regions (27; 29) Cultures were received both from Europe and from Hawaii, the species of most importance from the former place being *Botrytis tenella* (or *Isaria densa*), which is reputed to have been used with so much success at one time against the larvæ of *Melolontha* in France (29, p. 42).

From cultures received from Hawaii one species, that known as the Samoan fungus, or green muscardine fungus, *Metarrhizium anisopliae*, was succeessfully established on the Island, and large numbers of May-beetles were infected by means of soil inoculations (29) (See Pl. IV, figs. 7, 8, 9.) It was later learned that a local form of this fungus had already existed on the Island prior to the introductions from Hawaii, as grubs and beetles infested with the fungus were found in parts very remote from where liberations of spores had been made (12; 30).

Several liberations of the spores of *Metarrhizium* have been made by the pathologists of the Station, Mr. J. R. Johnston and Mr. J. A. Stevenson, the spore material having been grown in large cabinets on a scale surpassed only by the extensive liberations of *Metarrhizium* against the frog-hopper in Trinidad. The results of these liberations have been somewhat variable (25).

Method of Rearing Grubs.

Because of their subterranean habits, white-grubs are very difficult to rear to maturity, and to observe their molts. Living in tunnels in the soil, they are apt to be injured or set back in growth by being disturbed. Difficulty rests also in their requiring so long to reach maturity, their life-cycles in many cases covering a period of more than a year, which promotes the possibility of their succumbing to fungus and other diseases contracted through artificial means.

It is possible that the difficulties of rearing white-grubs in confinement are less felt in the tropics than in temperate climates because of there being no period of cold weather through which the grubs must be given special care and treatment. This advantage, however, is in part counteracted by the increased activity of certain parasitic fungi and other diseases that attack the grubs in warmer climates.

Perhaps the most careful methods of rearing grubs in temperate climates have been worked out by Mr. J. J. Davis at Lafayette, Indiana (5). His method consists, briefly, in the use of flower pots twelve to sixteen inches in diameter and height, or of cylinders made of metal and wire screening, twenty inches in diameter and two and one-half feet in depth, which are inserted into the ground in such a way as to give natural conditions of moisture and drainage. Necessarily cages such as these, even though each many contain several grubs, require a rather large amount of space for the rearing of large numbers of grubs; and it must be remembered that only in the results from rearing large numbers of grubs can accurate data be obtained. Under tropical conditions, where there is no winter to contend with, methods requiring much less space have been found quite satisfactory and in most respects preferable.

Methods of rearing employed by the writer consisted at first in the use of flower pots six inches in diameter and of glass battery jars. The objection to the pots was that they required dumping of the earth in order to view the grubs, which meant disturbance and often injury to the grubs. The objection to the jars was that they allowed for no drainage, and the soil became sour, thus permitting mites and nematodes to breed. Furthermore, in glass jars grubs would seldom remain near enough to the glass to be seen, so there was no advantage gained.

In all respects the most convenient method was found in the use of two and one-half and three-inch round, seamless tin boxes, one and one-quarter inches high. One or two grubs were kept in each box, the larger grubs being kept in larger boxes. These boxes were conveniently kept in piles and tiers, and were opened and the contents examined regularly at intervals of several days to a week or more. Pupæ were examined almost daily. To prevent rust boxes were first lined with a thin coating of paraffin. Moisture was regulated not by adding water to the box, which experience proved was dangerous, but by using sifted earth of the right dampness to begin with, and renewing the earth when it became dry or sour.

Food was supplied by adding a kernel of corn to each box. A new kernel was never added until the old one had been entirely consumed, germinating roots and all, as it was found that greater danger came from over feeding than from under feeding. Too much food in a box always led to an accumulation of mites (*Tyroglyphus* sp.?), which would attack and often sicken the grub, finally causing its death unless the mites were carefully brushed off and fresh earth supplied. In absence of corn, a small section of cane could be fed;

but cane quickly soured and nearly always gave rise to mites, so that use of corn was preferable.

Movements of the grub in a can have a tendency to pack the earth, so that by careful manipulation of a knife blade the top earth may be removed and the grub's tunnel exposed. A tunnel averages three to four times the length of the grub's body; and when one part of the tunnel is opened the grub rushes to the other extremity, so that there is small danger of injury. The grub may thus be viewed without disturbing it to any great extent.

When a grub is first added to a can, the latter is filled even full with sifted (not too fine) moist earth, and with the thumb or finger a pit is compressed in the soil, into which the grub is placed. It is never covered with earth.

There is little to be improved upon in the matter of convenience in the methods described here, provided care is taken; nor is there any more divergence from natural, outdoor conditions than would be the case in using larger boxes, jars, or pots. Check experiments proved that there was no difference in the time of emergence between adults from grubs in tin boxes and adults from grubs outdoors, provided a grub escaped the attack of mites, fungus, or bacterial disease. The presence of these diseases in small boxes was in most cases induced by over feeding, excessive moisture, or careless handling.

Check experiments for each species were run in large outdoor rearing cages, containing a depth of six to ten inches of earth in which was grown cane or corn as food. Cages were of uniform size, three by six feet and three feet high, screen covered with wooden bottoms, set up on posts as protection from ants and rodents. Adults were usually liberated in them in quantity, one species in each, at about the same time that other series were confined in jars for eggs. After a week or so of confinement adults were removed, eggs having been deposited in the soil. The cage remained undisturbed, except to be regularly watered and occasionally replanted to fresh cane or corn, until sufficient time had elapsed for grubs to mature and adults to issue.

In these cages the time required for emergence tallied very closely with the time required for grubs confined in tin boxes, showing that soil conditions in the smaller tin boxes did not change the time of emergence from normal.

In the case of one species, *Phytalus insularis*, no larvae reared in tin boxes were successfully brought to maturity, so that results obtained

from the large outdoor cages were depended upon in determining the length of the life-cycle.

OVIPOSITION AND HANDLING OF EGGS.

Some difficulty was experienced in determining the possible duration of oviposition by female adults. When beetles were confined "en masse," that is, a number in a cage or jar, there was usually a heavy mortality, which may have been due to the fungus disease, *Metarrhizium*, being able to communicate itself from one beetle to another.

The obstacle to confining females singly for oviposition may be realized when one takes into account the difficulty of giving the beetle sufficient living food material and freedom of movement, and at the same time restricting the amount of soil to a quantity not too large to sift and examine in a reasonable length of time. Beetles had to be confined in numbers, and the earth examined at frequent intervals, to give oviposition records value.

At first beetles were confined over potted plants; but it was found too difficult to extract eggs from among roots without crushing them. Also, the effort of supplying a fresh plant for each beetle at each examination of the soil was considerable.

Later experience showed that a beetle requires neither to fly nor climb in order to maintain a fairly normal existence in confinement. A method devised was to confine each female in a small glass battery jar, four inches in diameter by six inches high, in the bottom of which was placed two inches of moist earth, sifted to a fineness somewhat smaller than the size of the eggs, so that the latter were easily sifted out. The soil was packed lightly with the hand, and a few strips or sections of banana leaf put in above the soil as food for the beetle, being first dipped in water, after which they remained green for two or three days and were relished by the beetles.

It was not found necessary to confine adults in pairs in order to secure fertile eggs. There was no advantage in doing so, as copulation never took place to the writer's knowledge in small jars. Beetles collected immediately following copulation remained fertile for two months or more. No cases were observed of infertile eggs from females confined alone, except those from reared females, which of course had never copulated.

The first method devised for rearing the eggs was to place each one in a small pit made with the head of a match in the flat side of a small ball of damp soil or mud, and to press a tier of these

against the glass on the inside of a jar, around the circumference of the bottom, so as to expose the eggs to view. The space was filled in with sifted soil even with the tops of the earth balls, another tier added, and so on until all eggs of a lot were placed. Corn was not planted then until all eggs had hatched, as otherwise the germinating roots grew into the egg cavities and smothered the eggs or obscured them from view. Eggs were never put loose into a jar and covered with soil, as they must have room to swell, being laid under natural conditions in small cavities made by the female ovipositor which allow for swelling. (See Plate V, fig. 9, and Plate VI, fig. 3.)

A better and simpler method was to place the eggs over damp soil in shallow glass petri dishes. Being tightly closed, and of small size, these dishes maintained the required humidity, and a great many eggs were thus easily attended to and examined in a short time. As the eggs hatched, the young grubs were removed to tin boxes. With this method, care must be taken of two things: one, that the petri dishes remain in a place of little exposure and of uniform temperature; and two, that the soil be sterile, to insure it against mites and nematodes, to both of whose attack May-beetle eggs seem to be very susceptible.

Boxes for grubs just hatched should have the soil sifted, quite moist, and packed very gently if at all. Small pits were made in the soil with a match, and the grubs placed into these; if placed on the surface of soil they are often unable to penetrate. No planting of corn was required in the boxes until grubs were nearly ready to molt, as very young grubs were observed to feed almost entirely upon organic matter in the soil, and seldom to touch roots.

PUPÆ AND EMERGENCE OF ADULTS.

Before pupating, a May-beetle grub assumes a soft, flabby condition, during which it lies inertly on its back at the bottom of the tunnel. This is known as the prepupal stage. Prior to changing to the prepupa, the grub shortens and somewhat broadens its tunnel, making it very hard and smooth on the inside. In the cell so formed it undergoes the change to pupa and then to adult.

Whenever possible, it was found preferable to leave the pupa in its natural pupal cell, simply making an opening in the top of the cell through which it could be viewed. The use of the shallow tin boxes made this possible. When necessary, however, a smooth artificial cell open at the top was made in the soil in a tin box, and

the pupa placed in it on its back. Soil during the pupal stage must be kept uniformly moist, and mites must be guarded against.

In the field, pupation takes place usually at a depth of one and one-half to two feet, which is a foot or more deeper than the larva lives, and this going to a lower level is attributed to an instinct on the grub's part to avoid changes of temperature, and disturbances of the soil by plowing, that would take place nearer the surface. It seems, however, that it is simply a provision to so place the pupal cell that the inactive pupa will not be crowded and eventually smothered by the penetration of roots into the cell, which would undoubtedly take place near the surface of the soil in a field. Grubs in the tin boxes showed no discomfort at being prevented from penetrating to a depth in the soil.

The freshly issued adult (Pl. IV, fig. 6) was left in the pupal cell in the box for several days, to observe its changes in color in reaching maturity. In a week's time or less, before the beetle had shown a desire to leave the cell, a round disc of blotting paper was snugly fitted into the box over the earth and cell, and the box was buried, with lid removed, under several inches of damp earth in a jar or pot, the earth packed somewhat, and a cover or cage put over the top in order to determine the date of emergence from the soil.

Species of Porto Rican Melolonthids.

All five species of Porto Rican Melolonthids that have been segregated and studied are new to science. The four indigenous species of *Phyllophaga*, or May-beetles, are being described by the author under the names *Phyllophaga vandinei*, *P. portoricensis*, *P. guanicana* and *P. citri*, and the single species of *Phytalus* under the name *Phytalus insularis*.

The characters which distinguish the species are sufficiently marked to readily separate them from allied species occurring on the neighboring islands. In the present paper will be given only the more important characters necessary to distinguish one species from the other.

As the four species of *Phyllophaga* fall naturally into two groups, readily distinguishable by size and other gross characters, and as the two species of each group are restricted to well-defined geographic areas on the Island, one can almost with certainty determine the species by the locality in which it was collected, knowing the appearance of each group. The males of the four species can be separated by the characters shown in figures 4, 5, 6 and 7, of Plate V.

which illustrate the male genetalia viewed from the left side. The characters of the female genetalia are less well defined in the two species of either group, but those of the two groups are quite distinct in appearance, as is shown by figures 8 and 10, Plate V, representing one species of each group.

The species *Phytalus insularis* conforms with the described character separating the genus from *Phyllophaga*. This consists in the tooth of the tarsal claw being situated near the end of the claw, and directed at an acute angle instead of at an obtuse or right angle to it, making the claw what is termed "cleft." This character is more or less variable with other species of *Phytalus*, but holds good in the case of *P. insularis* and *P. smithi* Ar.

A notworthy fact is that all of the Porto Rican Melolonthids, including *Phytalus*, in common with the species from neighboring islands, possess certain marked characters not ocurring in the species from the mainland which have been examined. This would seem to set them apart as belonging to another genus. These characters consist in: (1) the presence, on the inner posterior angle of the femora of the hind pairs of legs, of a longitudinal row of prominent, stout, rather blunt spines, varying usually from three to five in number, and below each spine a long bristle—where in the species of the continent this angle is bare of spines and has few, if any, bristles; (2) the constriction of the transverse, sub-median ridge on the outer face of the back tibiae, which in American continental species is directed downward and bears a prominent row of bristles, or slender spines, into an anterior and a posterior flattened spur, the former bearing from three to five bristles and the latter from one to four bristles; and (3) in the presence, above the posterior flattened spur and less than midway between it and the base of tibia, of another flattened spur, bearing from one to three bristles—which in continental species is indicated, if at all, by no more than a slight elevation above a pit bearing one bristle. Occasionally, in Insular species, there is a third flattened spur above this last, having one to two bristles.

These characters of the rear tibiae occur in the West Indian species of *Phytalus* as well as in *Phyllophaga*, and make it appear that the West Indian species of *Phyllophaga* are a link between *Phytalus* and the *Phyllophaga* of North America.

CHARACTERS IN THE GENITALIA.

It is well known that many species of *Phyllophaga* of the American continent are practically indistinguishable from external char-

acters, and that it is necessary to extract and examine the genitalia in order to separate them. The same is true of Porto Rican species, especially as regards closely related species in either group. Of the two sexes, the genitalia of the male are the more highly specialized, and therefore of greater use in separating species.

The genitalia of a male *Phyllophaga* may be described as a semi-chitinous, tubular, protractile organ whose distal end, for about one-third of the entire length, is enlarged and modified into a collar, or theca, which is parted longitudinally on the ventral side. The theca is articulated at the sides to the upper or proximal portion of the genital organ, the dorsal suture being protected by a tympanum. The distal margin of the theca is nearly circular and cuplike, concealing the fleshy phallus; the ancipital margins on the ventral side are variously modified into corneous hooks or barbs. In many American species of *Phyllophaga*, including such species as *hornii*, *ilicis* and *bipartita*, the theca is greatly modified, becoming articulated on the dorsal side and formed into two highly specialized claspers, which are dissimilar in shape. In other species, such as *quercus*, *rubiginosa* and *forbesi*, the theca is bilaterally symmetrical and more regular in shape, as is the case with Porto Rican species. In none of the American species, however, is the phallus (which may be known as the median lobe of the genital organ) highly specialized as in the species of the Island.

The median lobe of the male genitalia of Porto Rican species bears, normally, a superior, deflexed, acicular process, or spicula, which is roundly bent toward the right, and an inferior pair of adnate, falciform armatures, which cross scissor-like at their bases and re-cross, or at least meet, at their tips. (See Pl. V, figs. 6 and 7.) In the group including the two species of smaller size (*guanicana* and *citri*) the adnate armatures are fused into a single spatha, which is in one case fleshy (*guanicana*) and in the other case chitinous (*citri*). In the group including the two larger species (*vandinei* and *portoricensis*) the adnate armatures are distinct, chitinous, dark brown and shining, the dextral armature superior and the sinistral inferior; they are compressed or cylindrical at their bases and depressed at the tips, which lie one over the other. The distinguishing characters lie in the structure of the tips of these armatures, which are bicuspidate in one (*vandinei*) and spatulate in the other (*portoricensis*).

The female genitalia consist, in American species, of two pairs of flattened plates, an inferior and a superior, the latter extending beyond the former, and above the superior plates, at their suture, a

pubic process of varying form, which is often lacking or concealed. The inferior and superior plates are often fused together. Among Porto Rican species this seems to be the case, and the pubic process is visible only in species of the larger group (*vandinei* and *portoricensis*).

The following key will serve to separate readily the five Porto Rican *Melolonthides:*

KEY TO PORTO RICAN MELOLONTHIDES.

A. Theca of male genitalia cyanthiforn, closed ventrally. *Phytalus.*

B. Theca of male genitalia collar-shaped, open ventrally. *Phyllophaga.*

- *a.* Adnate armatures distinct and chitinous; spicula medial; female genitalia with prominent pubic process. (Group of larger species.)
  - I. Armatures bicuspidate at tip; spicula sharply deflexed. *P. vandinei.*
  - II. Armatures spatulate at tip; spicula roundly deflexed. *P. portoricensis.*
- *b.* Adnate armatures fused into a single spatha; spicula dextral; female genitalia without pubic process. (Group of smaller species.)
  - III. Spatha fleshy, surmounted by minute prostrate spinules. *P. guanicana.*
  - IV. Spatha cymbiform, chitinous and polished above. *P. citri.*

Phyllophaga vandinei n. sp.[1]

This species has been named for Mr. D. L. Van Dine, the first entomologist of the Experiment Station of the Porto Rico Sugar Growers' Association, who, by reason of his characteristic zeal and energy, was largely responsible for the extensive importations of white-grub parasites and for instigating the work carried on with the sugar-cane white-grubs of the Island in the past five years.

The larva of this species is the worst sugar-cane pest of the Island, and is perhaps one of the three most injurious sugar-cane white-grubs in the world. Its habitat on the Island is restricted to the western end, its farthest east recorded occurrence being at Manatí on the north coast and at Peñuelas on the south. Within this limited territory it has reached, particularly in the Guánica district, such great abundance as to often have caused whole fields of cane to fall prone and to begin to sour in a week's time after damage first became evident. It has made the growing of ratoon cane in the Guánica and San Germán districts impossible, and in addition to the cost of replanting for each crop, has levied a tax upon the centrals for the continued hiring of boys to collect the grubs and beetles that amounts to hundreds of dollars in a single season.

[1] Technical description of this and the other species will be published later.

Cases are on record where over fifty grubs of this species have been spaded out from under a single stool of cane. It is no uncommon occurrence to dig out twenty or more grubs from one cane stool. So prolific is the species that it requires constant vigilance on the part of the sugar centrals of the infested district to keep the insect in check. Boys are paid at a regular rate per quart for beetles collected on the cane foliage by lantern at night, and women are paid by the quart for grubs collected in the plowed fields in the daytime. By these means hundreds of bushels of beetles (see Pl. II, fig. 4) and grubs are collected every season and destroyed, or fed to hogs.

Some idea of the cost of this propaganda may be derived from the following figures, available through the courtesy of the general manager of Guánica Centrale, where accurate records of the daily collections of grubs and beetles are kept:

In seven months of 1914 during which collections of beetles were made (February 27 to September 23), the total collections in five *haciendas* belonging to Guánica Centrale amounted to 2,255,000 beetles, gathered at a total cost of $833.87.

The collections of grubs for six months of the same year (from November 27, 1913, to May 14, 1914) amounted to a total of 1,662,000 grubs, gathered at a cost of $1,876.73.

In six months of the following year (March 6 to September 9, 1915), on the same *haciendas* of Guánica Centrale, the collections of beetles amounted to a total of 2,468,000, gathered at a cost of $1,425.20.

The number of grubs collected in seven months of 1914 and 1915 (from October 29 to May 27) amounted to a total of 2,425,000, gathered at a cost to the central of $2,018.57.

Figuring 400 beetles to the quart, and 300 grubs to the quart, this makes the rather startling figure of 369 bushels of beetles and 426 bushels of grubs collected in two years from a small district by one sugar central, at a total cost of $6,154.37.

And still this beetle is not held in check, but appears to continue to increase in abundance. It is small wonder that the sugar-cane growers of Porto Rico have become exercised over the depredations of the "gusano blanco," as the white-grub is known locally.

THE BEETLE.

The adult of *Phyllophaga vandinei* is a May-beetle of normal appearance, smooth and faintly shining in both sexes, but not pol-

ished, tawny to chestnut brown in color, and varying from 17 to 22 mm. in length. (See Pl. IV, fig. 3.) From *P. guanicana* or *P. citri* it is at once separable by its larger size, lighter color and smoother surface. From *P. portoricensis* it is distinct in being confined to a different habitat, as well as by the characters cited in the preceding table.

Unlike most species of *Phyllophaga*, *vandinei* may be found in some abundance in the fields throughout at least eight and often nine months of the year. In the Guánica district, where it has been closely studied, it makes its first appearance during the last days of February, and by the last of March is abundant, remaining so from then up until late in September or the middle of October, when it rapidly decreases in numbers; and by the second week of November few are to be found in the fields. During the two years of 1914 and 1915, figures compiled by Guánica Centrale show that the beetles were most abundant in 1914 from the last of July to early in September, while in 1915 they were most plentiful from the middle of April to early in July. These variations may be due to climatic conditions in individual seasons.

As the life-cycle of the species covers only one year, or a period of ten months for the actual egg-to-adult cycle, and as there is a possible variation (as shown by breeding experiments) in this cycle ranging from seven to thirteen months, it is evident that there must occur an overlapping of broods, to such an extent, in fact, as to distribute the emergence of adults over all of the summer months.

THE LIFE-HISTORY WORK.

As this species is the worst cane pest of the Island, and the ultimate object of all the experimental work on white-grubs was to find a practical method of controlling it, the laboratory-insectary erected for its study, and called the South Coast Laboratory, was located at Santa Rita, midway between Guánica and Yauco, in the heart of the district worst infested by this beetle. Most of the white-grub work was put upon the one species, with the result that its habits and life-history are better known than those of any other species occurring on the Island.

More than twenty individuals of *Phillophaga vandinei* were reared from egg to adult, and twice as many more were reared successfully to the pupal stage. Many hundreds of eggs from confined adults were kept under observation, and the grubs hatching from them were fed and regularly observed; but a majority of these died

before reaching maturity, some from disease or from the artificial conditions of their confinement, others from wrong handling through ignorance of the essentials for their growth. The total number of eggs, larvæ, and pupæ of this species whose molts and instars were recorded was as follows: Eggs, 1,502; grubs in first instar, 852; grubs in second instar, 209; grubs in third instar, 117; pupæ, 46.

The two charts on Plate VIII show in graphic form the length of the egg to adult period of *Phyllophaga vandinei.*

LENGTH OF LIFE-CYCLE.

The life-cycle of *Phyllophaga vandinei* covers, roughly speaking, one year. The average normal egg-to-adult period covers just ten months. The average from fourteen complete records of single individuals run from egg to adult was 306 days; the average obtained by adding together the average lengths of the three immature stages—the egg, three instars of larva, and the pupa—was 302 days. The disparity is easily accounted for.

The maximum egg to adult period of the fourteen individuals was 395 days; the minimum, 212 days. Or in terms of months, they were, respectively, 13 and 7 months.

Observation has shown that the adult beetle, after issuing from the pupa, may remain in the soil in the pupal cell for a period varying from two weeks to perhaps two months. The period of pre-oviposition of adults was not experimentally determined, because of the refusal of reared specimens to oviposit, and the difficulty of being sure whether specimens collected in the field had just emerged or not. Calculating the pre-emergence period to average a month, and the pre-oviposition period to require close to a month, the species is seen to have a life-cycle of virtually one year.

The possible shortening or lengthening of the egg-to-adult period by three months, which was demonstrated in rearing boxes, and which would shorten or lengthen the entire life-cycle by an equal period, gives the life-cycle of the species a proven variation of nine to fifteen months. This might be still further lengthened by the fact that the egg-laying period of the female may extend over a period of more than a month.

It is very conceivable that an egg laid quite late in the fall might not, under adverse conditions, emerge as an adult until the spring of the second year following; or on the other hand, that an egg laid in spring might, under very favorable conditions, produce an adult in the fall of the same year. This last, in fact, happened in one of

the rearing boxes (see Plate VIII, No. 1211*a*), although there is no way of knowing whether the adult would have emerged from the ground in the fall, under natural conditions, or would have remained in the pupal cell until the following February or March. All of which readily explains the occurrence of adults in the cane fields throughout most of the year.

THE EGG STAGE.

The average length of the egg stage, from the date it is laid to the date of hatching, was determined as fourteen days. This average was secured from a total of 1,089 eggs, the hatching of which was observed. The maximum length of egg stage was seventeen days, recorded in March, and the minimum ten days, recorded in September.

Description.—The egg of *Phyllophaga vandinei* is opaque and pearly white in color (in that regard resembling the eggs of other species of the genus). When first laid it is slender oblong-oval in shape, about 2.75 mm. to 3 mm. in length by 1.62 mm. to 1.75 mm. in breadth. It swells greatly before hatching, and becomes almost spherical, 3 mm. to 3.25 mm. in length by 2.35 mm. to 2.65 mm. in breadth. (See Plate III, fig. 1.)

Eggs are deposited among roots in the soil in small globular pits, or cavities, which are made by the ovipositor of the female. One egg is laid in each pit and rests at the bottom. (See Plate V, fig. 9.) The earth forming the walls of the pit is cemented or compressed in such a way that even in dry sifted soil the pits usually remain intact, when the soil is sifted, until put under pressure of the thumb. The pit varies from two to three times the diameter of the egg, and serves to maintain a uniform humidity as well as to prevent the soil from touching the egg. When fully swollen the egg does not completely fill the pit, so that when it hatches the grub, which is half again greater in diameter than the swollen egg (see Plate III, fig. 2), has a natural cell in which to move about and begin existence.

THE WHITE-GRUB, OR LARVAL STAGE.

In common with other white-grubs, the larva of *Phyllophaga vandinei* molts its skin three times, passing through three distinct instars. In computing the length of life-cycle the average, maximum, and minimum lengths of each instar were found.

Of fifty larvæ of this species reared from egg to pupal stage, in which the exact dates of hatching of egg and of pupation were re-

corded, the average length of larval stage was 267 days; the maximum, 356 days; the minimum, 179 days. Or, reduced to months, the average length of larval stage was about nine months; the maximum, twelve months; and the minimum, six months. It is at once apparent that the astonishing variation in the length of life-cycle of this species is due to the variation in length of the larval, or grub, stage, the egg and pupal stages showing very little variation in duration. (See charts on Plate VIII.)

Nine out of ten months (or 90 per cent) of the insect's normal life below ground are spent in the larval, or grub, stage. During most of this time the grub is doing actual damage to cane by feeding upon the roots.

The length of larval period, secured by adding together the averages of the three instars, amounts to 266 days. This constitutes a very good check on the above average of 267 days, computed from the whole larval stage of 50 larvæ, since a good many of the grubs from which the instar averages were taken never reached pupation, and conversely, a majority of the grubs whose exact dates of egg hatching and of pupation were recorded, were not observed and recorded as to their molts; so that the two results were taken to a large extent from different series of grubs.

The explanation for fifty grubs having reached the pupal stage, whereas only about twenty reached the adult, lies in the fact that at the time of pupation the grub is particularly susceptible to injury by handling, or by attack of the bacterial disease, *Micrococcus nigrofaciens* Nor. (17). Many grubs while active seemed to resist the disease, which attacked a majority of them, but during the quiescent prepupal stage they succumbed. The presence of mites on the body of a grub would often prevent its pupation, or cause the pupa to be deformed, and the adult would not issue.

The first instar.—Technical descriptions of this and the other instars and stages of *Phyllophaga vandinei* will be given in a later issue of the Journal, when detailed studies have been completed. For the present, the plates may be depended upon to give a fairly accurate impression of the size and appearance of the different instars of the grub.

The average duration of the first instar was determined as 36 days; the maximum, 59 days (in December); the minimum, 17 days (in June). The maximum duration was found to be more than three times the minimum. The duration of this, as well as the other instars of the grub, has been shown to be influenced more by the amount of moisture in the soil, and by the presence or absence of mites, fun-

gus or bacterial disease, than by the amount of food provided the grub. (When grubs succumbed to the *Metarrhizium* fungus during the second or third instars, it was found that the earlier instars had been above normal in length.)

From the fact that larvæ of May-beetles are always in a coiled position, and seldom straighten out to crawl as do the grubs of Rutelids and Dynastids, it is very difficult to measure their length. It was ascertained, however, that the length is just double the measurement across the coiled body, so that the length of grubs in the various instars was determined in this way.

At the time of hatching from the egg, the grub of *vandinei* is about 6 mm. long and 1.75 mm. to 1.8 mm. across the head. Before molting to the second instar (see Plate III, fig. 3) it reaches a length of 17 mm. to 18 mm., and the head reaches a diameter of 1.9 mm. to 2 mm. (Pl. V, fig. 1.)

The head does not grow like the body, but that it enlarges somewhat in size may be shown by the following brief table, from actual measurements with sliding calipers from living grubs:[1]

HEAD OF FIRST-INSTAR GRUBS.

An average from 5 grubs varying from 5 to 10 mm. in length: head 1.85 mm. wide.

An average from 29 grubs varying from 11 to 15 mm. in length: head 1.96 mm. wide.

An average from 11 grubs varying from 16 to 18 mm. in length; head 2.01 mm. wide.

During the first instar no damage is done by the grub of *vandinei*, since it lives entirely upon vegetable matter in the soil. It is only during the very last days of the instar, or more commonly in the early part of the second instar, that the grub begins to eat living roots.

The second instar.—The average duration of the second instar (see Plate III, fig. 4) was found to be 47 days; the maximum, 103 days; the minimum, 26 days. Or, reduced to months, the average was one and one-half months; the maximum, three and one-third months; and the minimum, somewhat under one month. It is seen that the maximum duration of this instar was more than four times the minimum.

At beginning of the second instar the length of the grub is 17 mm. to 18 mm.; at end of the instar, and just before molting to the third instar, the length is 28 mm. to 30 mm. The average width of head, taken from 43 second instar grubs, was 3.33 mm. (See Plate V, fig. 2.)

[1] NOTE.—Measurements of small objects made with sliding calipers are very apt to average from .1 mm. to .15 mm. above actual size.

An idea of the enlargement in the head during the second instar may be gained by the following figures, taken from measurements of living grubs:

HEAD OF SECOND-INSTAR GRUBS.

An average from 23 grubs varying from 18 to 25 mm. in length; head 3.25 mm. wide.

An average from 20 grubs varying from 26 to 30 mm. in length; head 3.42 mm. wide.

The third instar.—The average duration of the third instar, from records of 25 grubs, was found to be 183 days; the maximum 266 days; the minimum, 78 days. Again, the maximum duration of the instar is more than three times the minimum. Reduced to months, the average length of the third instar is six months; the maximum, nine months; and the minimum, two and one-half months.

Approximately two-thirds of the larval period is spent in the third or last instar, or about three-fifths of the entire life of the immature insect. During more than six months of the year this insect is doing great injury to crops in the soil as a grub. There being no winter in Porto Rico during which the grub is not feeding, its activity as a root trimmer extends not only through five and one-half months of the third instar (allowing one-half month for the quiescent, pre-pupal stage), but also through the month and a half of the second instar, so that the period of injury may easily cover seven months.

At beginning of the third instar (see Plate III, fig. 6) the grub averages about 28 mm. in length, and when full grown (see Plate III, fig. 7) it reaches a length of 40 mm. to 44 mm. The average width of head from 96 grubs measured in the third instar was 5.29 mm. (See Plate V, fig. 3.)

The rate of growth of the head during this instar may be seen from the following table:

HEAD OF THIRD-INSTAR GRUBS.

Average from 30 grubs varying from 26 to 30 mm. long; head 5.13 mm.
Average from 19 grubs varying from 31 to 35 mm. long; head 5.26 mm.
Average from 42 grubs varying from 36 to 40 mm. long; head 5.39 mm.
Average from 5 grubs varying from 41 to 45 mm. long; head 5.45 mm.

The factors which influence the rate of growth in the third instar of the grub are:

(1) Available food supply; *i. e.*, contiguity of abundant living plant roots.

(2) Humidity and texture of soil. Hardness or softness of the

soil naturally retards or facilitates the easy movements of the grub in its constant search for fresh roots. For this reason white-grubs are worse pest in friable than in heavy clay soils.

(3) Temperature (time of year). The length of this instar somewhat increases, as do the others, during the winter months, though at no time of year do the grub's activities entirely cease as result of cold weather, as happens in more northern latitudes.

(4) The presence of disease in the grub. As previously stated, infection with the *Metarrhizium* fungus greatly retards the activity and growth of the grub, as does bacterial infection, thus lengthening the duration of the instar.

(5) Attack by mites, or by other dermal parasites that molest the grub.

THE PRE-PUPAL STAGE.

The so-called pre-pupal stage of white-grubs is the resting period that occurs at the end of the third instar during which the grub is preparing for pupation. It is characterized by a puckering or gathering of the skin, general flabbiness, and a discoloration or yellowing in color (see Plate III, fig. 8). The larva lies on its back, dormant, in a rounded, oblong cell about 35 to 40 mm. long; the body is much flattened and the caudal end rather sharply bent upward; the legs are held stiffly outward, close together, and display little or no movement. There is no molt between the third instar and the pre-pupal stage.

From two weeks to a month prior to the pre-pupal stage, the grub shows the approach to pupation by its sluggishness, by the body becoming yellow, more opaque, and harder to the touch, and by a disappearance of the dark stain at the caudal end of the body resulting from the earthy excretions matter within.

From about a dozen observations of reared grubs, the pre-pupal stage varied from four to seven days. There was in each case an added period of about a week to two weeks during which the grub was sluggish and did not feed, thus indicating its preparation for the pre-pupa.

THE PUPAL STAGE.

When the pre-pupa molts, the pupa is at first white and misshapen; but within twenty-four hours it has assumed its natural shape (see Plate III, fig. 9; also Plate IV, figs. 1 and 2) and shining yellow-brown color. The pupa lies on its back in the cell, and the

crumpled molt skin (Plate III, fig. 9) remains near it, at the caudal end.

The average duration of the pupal stage, from 22 observations, was $21\frac{1}{2}$ days; the maximum, 26 days; the minimum, 17 days.

From thirteen measurements, the average length of the pupa was 25.1 mm., the average width 11.15 mm., and the average breadth of the head 8.18 mm.

A day or two before hatching into the adult, the pupa turns over in its cell and lies with the back upward. In this position the adult is always found in the cell, never with back downward. On a pupa about to hatch the skin is wrinkled, and the white color of the elytra may be seen through elytral sheaths. (See Plate III, fig. 10.) The formation and sculpture of the legs may also be seen through the now transparent pupal skin.

ISSUING AND EMERGENCE OF ADULT.

An adult just issued has only the legs, head, and thorax brown the elytra being white and soft, and the wings extended their full length beneath the elytra. (See Plate IV, fig. 6.) In a few hours the beetle turns tawny yellow in color, then gradually deepens in shade during the following week.

The term issuing applies to the breaking of the pupal skin, and the exit of the newly formed adult from the pupa; the term emergence applies to the appearance of the beetle above ground. The interim between these two periods is spoken of as the period of pre-emergence, and is the time spent by the newly-hatched beetle in the pupal cavity in the soil—a time very necessary for the chitinous parts of the beetle to become perfectly hard, so that it can dig its way upward to the surface of the ground.

In many North American May-beetles the pre-emergence of adults covers a period of several months—usually from the late summer or fall of one year to the spring of the next. In the Porto Rican species this period extends rarely over five to six weeks, judging from observations.

Because of the fact that most of the confined specimens of *vandinei* were reared in small tin boxes, in which the adults at time of pre-emergence were disturbed and did not behave normally, our records of pre-emergence are somewhat incomplete. The following notes, however, prove it to extend over a period of two weeks or more:

(1) *No. 547.*—On July 1 two adults hatched from pupae in earth in a jar,

which were still alive in the cells but had not come to the surface of ground when the soil was dumped, July 30. Time, over 29 days.

(2) *No 548.*—One female and two male adults, hatched in a battery jar on July 3, 7 and 18, respectively, had not reached surface by July 30, though two of them were still living. Time, over 12 to 27 days.

(3) *No. 1172c.*—A female, issued April 12 in a jar, had not come to the surface on April 28, though still living. Time, over 16 days.

(4) *No. 1219b.*—A female hatched February 15 and had not come to surface through four inches of damp soil by March 10, though still alive. Time of pre-emergence, over 23 days.

DISTRIBUTION OF THE SPECIES.

Phyllophaga vandinei is confined to the western end of the Island, a territory equivalent to about one-third of the area of the Island. Its eastern distribution may be defined, roughly, so far as our present knowledge goes, by a north and south line across the Island through the towns of Manatí on the north and Peñuelas on the south. The type of the species is from Santa Rita, near Guánica.

The analogue of this species at the eastern end of the Island is *Phyllophaga portoricensis*, which is indistinguishable from the former species except by means of the genital characters given in the table. It is indeed possible that the two are but races of one species, for there seems to be a general intergrading of the characters along the geographic line separating the two species. Yet at no time have the two been taken in one locality; and the specific characters are sufficiently recognizable in specimens from the type localities, Guánica and Río Piedras, to set apart the species as quite distinct.

FEEDING HABITS OF THE ADULTS.

All May-beetles feed upon the foliage of plants and trees, and are voracious eaters. The adult of *vandinei* differs from many species of the genus in being a very general feeder, and there are few plants which it will not touch. Feeding is done entirely at night, the adults issuing from the ground at dark, or a little before. After a very brief flight, they alight upon suitable foliage and begin to feed upon the margins of the leaves. Feeding continues until very late into the night, the beetles appearing to be as abundant after midnight as before. Spending thus six hours or more of the night in feeding, they consume quantities of vegetation. Small tress of "quenepa," of "saleilla," and of native china-berry have been found completely stripped of foliage by this species. Cane also suffers from depredations of the adults, but not to such an extent as the foliage of certain trees. A common ornamental tree of the south side of the

Island, the casuarina, and another of general use along roads in Porto Rico, the flamboyant, are both very badly attacked by adults of this species. Banana and coconut trees often show acute injury from their feeding. (See Plate I, figs. 1 and 2.)

It has not yet been determined at what hour of the night their feeding terminates, but it must be well toward morning, as they have been collected feeding as late as 2 a. m. Nor is it known whether, at termination of feeding, they fly or drop to the ground. When disturbed in feeding they drop, using the wings usually to carry them a short distance; and this is probably the method employed at the end of the feeding.

So uniformly abundant is *Phyllophaga vandinei* over the infested area that unusual and sporadic appearance of adults in such numbers as to cause bad defoliation in restricted areas is rare. The infestation is general, and usually heavy. Cane foliage may always be found somewhat damaged in the Guánica district and the San Germán valley.

Following is a list of some of the commoner plants and trees occurring in or near cane fields in the infested area, grouped according to their attractiveness to the beetles.

(1) Those greatly relished by the adults—

Flamboyant (*Poinciana regia*); Australian pine (*Casuarina equisetifolia*); almendro (*Terminalia catappa*); salcilla (*Schrankia portoricensis*); quenepa (*Melicocca bijuga*); guasima (*Guazuma guazuma*); China-berry (*Melia azedarach*); tamarind (*Tamarindus indicus*); jobo (*Spondias lutea*); banana (*Musa* sp.); coconut (*Cocos nucifera*); cecropia (*Cecropia palmata*); pig-weed, or bledo (*Amaranthus* spp.); mallow (*Malachra rotundifolia*); and *Petiveria alliacea*.

(2) Those eaten to some extent, but not apparently as much relished as trees and plants in the preceding list—

Sugar cane (*Saccharum officinarum*); guava (*Psidium guajava*); almacigo (*Bursera simaruba*); jaguey (*Ficus lentiginosa*; bucago (*Erythrina glauca*); royal palm (*Roystonea borinquena*); eucalyptus (*Eucalyptus* spp.) (very rarely); Jamaican sorrel (*Hibiscus sabdariffa*); native cotton (*Gossypium* sp.); Guinea grass (*Panicum maximum*); malojillo, or Para grass (*Panicum barbinode*); *Casearia sylvestris*; and *Cordia corymbosa*.

(3) Those which appear to be entirely exempt from attack by the adults—

Hawaiian algarroba (*Prosopis juliflora*); papaya (*Carica papaya*); gallito (*Sesbania grandiflora*); gandul (*Cajanus indicus*); pepper tree (*Schinus molle*); black sage (*Cordia cylindrostacha*); roble (*Tabebuia rigida*); calabash (*Crescentia cujute*); berengena cimarrona (*Solanum torvum*); silk cotton weed (*Calotropis procera*); acalypha (*Acalypha wilkesiana*); *Citrus* spp.; and *Clidemia* spp.

HABITS OF FLIGHT.

During the day the beetles conceal themselves by burrowing into the ground, usually near the bases of trees or large weeds. Often a dozen or more holes may be found around the base of a tree upon which they have been feeding. At night they begin issuing from these burrows at about sundown, and their flight seldom lasts for more than fifteen to twenty minutes.

On one occasión, in October, observations were made at sundown of a large screened cage into which had been put five hundred adults a few evenings before. The beetles began appearing from the soil at 6:25 p. m., were issuing in greatest numbers at about 6:35 p. m., and had practically ceased to appear by 6:45 p. m. The majority took wing immediately upon making their exit from the holes, or crawled up a near-by weed and then took wing; a few climbed weeds and began to feed without flying at all. Nearly all flew westwardly, against the western side of the cage. The flight of the majority lasted until about 6:50 p. m.; the last of them had ceased flying by 7:00.

Adults of this species do not usually fly for long distances. By watching up and down a "callejón" (a bare or grass alleyway 20 to 30 feet wide) between cane fields at about dusk, in a place where infestation by the beetles was known to be heavy, it has been noted that comparatively few of the beetles flew across the "callejón," but that the majority hovered over the cane plants very near to where they had arisen. On various occasions casuarina trees in a Bermuda-grass lawn were watched at dusk, and it was noted that the beetles usually hovered around the trees near whose bases they had made exit from the ground, but never arose high and took direct flight for more distant trees.

Another observation confirmed the belief that the dispersion of *vandinei* by flight is not extensive. In a large outdoor screened experimental cage, 6 by 10 feet in area, into which 2,000 beetles were introduced on April 2, it was observed a week later that the cane growing at the end of the cage where the beetles had been introduced was entirely stripped of foliage, while cane growing at the opposite end was virtually untouched, showing decidedly the slow dispersion by flight.

ATTRACTION TO LIGHT.

Adults of *vandinei* are quite readily attracted to light, as is usual with May-beetles. Experiments were made with a large 500–c. p.

Pitner gasoline lamp, with a view of finding some suitable method of taking advantage of this fact for the destruction of the beetles. The lamp was placed on the roof of a two-story building near the insectary at Santa Rita, and a canvas stretched on a vertical frame was put beneath the light. Since a few individuals often come to an ordinary lamp in a room, it was expected that the Pitner light, with its great power, would attract large numbers. This hope was not justified, as out of twenty-three evenings in July, August, October, and November during which the light was run, beetles were taken on only seven, a total of twenty-four being taken.

The reason for this scarcity of beetles was that the Pitner light was always started about 8 o'clock, and *Phyllophaga* adults are ordinarily only attracted to light during their flight and before they have settled on foliage to feed (before 7:30 p. m.). To have any practical efficiency in attracting *vandinei* adults for destruction, a light must be close to the ground, and must be started immediately at dusk, while beetles are flying. It need not be run for over an hour after dark, as time after that is wasted. There have been cases where adults of this species and *portoricensis* have left their feeding on the foliage and flown to a motorcycle headlight as late as midnight or after, but these cases are rare. Almost never, while collecting beetles with a bull's-eye light, have they been known to leave their feeding and fly to the light.

COPULATION.

This species is not often found in copulation in the field, the reason being that collecting is usually done after 8 p. m., while mating takes place before that hour. On one occasion recorded, when collecting was done between 6:45 and 8:25 p. m. (on October 14), out of 79 adults collected on cane, "salcilla" and "malojillo," only one pair was found in copula (at 7 p. m.). Lateness of the season may have accounted for so few being found copulating at that hour.

Pairs were occasionally found copulating on the foliage of small casuarina tress near the insectary. Pairs thus observed on two evenings in April were recorded as follows:

(1) Copulation began before 7:30; ended at 7:45; duration 15 minutes +.
(2) Copulation began before 7:30; ended at 7:53; duration 23 minutes +.
(3) Copulation began before 7:35; ended at 7:45; duration 10 minutes +.
(4) Copulation began before 7:35; ended at 7:48; duration 13 minutes +.
(5) Copulation began before 7:35; ended at 7:50; duration 15 minutes +.
(6) Copulation began before 7:35; ended at 7:50; duration 15 minutes +.
(7) Copulation began at 7:31; ended at 7:52; duration 21 minutes.
(8) Copulation began at 7:34; ended at 7:53; duration 19 minutes.

It is evident that copulation of this species takes place quite uniformly between 7 and 8 p. m., or immediately after the cessation of flight, and that the average duration exceeds sixteen minutes. It may possibly be learned, with further observation, that the oviposition of the Tachinid parasites, *Cryptomeigenia aurifacies* Wal. and *Eutrixoides jonesii* Wal., on the adult beetles takes plaee during the copulation and before the total darkness of night comes on.

OVIPOSITION OF FEMALES.

Oviposition takes place in the soil adjoining the beetle burrows at the bases of trees and plants, where the young larvæ will be immediately among the roots. Exact depth at which eggs are laid in the soil has not been determined, but probably averages from eight inches to a foot, the depth at which beetles are usually found in their burrows.

As stated before, to secure eggs in confinement for the purpose of determining the length of the period of oviposition of females and the average number of eggs laid by a female, beetles were confined both singly and "en masse;" and the results from the two methods did not vary much. The method of confining the females has been described on page 63. No eggs were secured from reared females, unfortunately.

The individual egg-laying records of females of *vandinei* are graphically shown in the two charts on Plate IX. The complete records are given in the following tables:

Egg-Laying Records of Individual Females of Phyllophaga Vandinei n. sp.

Exp. Number	Date	Days	Eggs	Days	Eggs	Days	Eggs	Days	Eggs	Days	Eggs	Days	Eggs	Days	Eggs	Days	Eggs	Days	Eggs	Days	Eggs	Days	Eggs	Days	Eggs	Days	Eggs	Days	Eggs	Days	Eggs	Days	Eggs	Days	Eggs	Days	Eggs	Lived Days	Laid Eggs	Eggs per Day
1192 *	3-8	2	0	3	0	3	0																															5—8	0	.000
" *	3-23	3	0																																			1—3	0	.000
1206	3-3	7	0	3	0	3	0	3	0	4	0	3	0	3	0	3	0	6	0	3	0	3	0	3	0	4	0	8	0	5	0							56—61	0	.000
1207	"	7	5	3	0	3	0	3	0	4	0	3	0	3	0	3	0	6	23	3	0	3	0	3	0	4	0											44—48	28	.609
1208	"	7	0	3	0	3	0	3	0	4	0	3	0	3	0	3	0	6	21	3	0	3	0	3	0	4	0	8	10	5	0	4	0	3	0	3	0	68—71	31	.446
1209	"	7	0	3	0	3	0	3	0	4	0	3	0	3	0	3	0	6	0	3	0	3	0	3	0	4	0	8	0	5	0	4	35	3	0	3	0	68—71	35	.501
1210	"	7	0	3	0	3	0	3	0	4	0	3	0	3	0	3	0	6	27	3	0	3	0	3	0	4	0	8	0	5	0	4	0	6	0	5	12	71—76	39	.531
1211	"	7	0	3	0	3	0	3	0	4	0	3	0	3	0	3	0	6	10	3	0	3	0	3	1	4	8											44—48	19	.413
1212	"	7	0	3	0	3	0	3	0	4	0	3	0	3	0	3	0	6	0	3	0																	35—38	0	.000
1213	"	7	0	3	0	3	0	3	0	4	0	3	0	3	0	3	0	6	20	3	0	3	6	3	0	4	9	8	10	5	0	4	0	3	0	3	0	68—71	45	.617
1214	"	7	0	3	0	3	0	3	0	4	0	3	0	3	0	3	0	6	23	3	0	3	0	3	0	4	0	8	6	5	0	4	0	6	0	9	0	76—80	29	.372
1215	"	7	9	3	0	3	0	3	0	4	0	3	0																									20—23	9	.419
1216	"	7	0	3	0	3	0	3	0	4	0	3	0	3	0	3	0	6	11	3	0	3	0	3	0	4	2	8	11	5	2	4	0					61—65	32	.508
1217	"	7	0	3	0	3	0	3	0	4	0	3	0	3	0	3	0	6	20	3	0	3	0	3	0	4	11	8	1									48—56	32	.615
1218	3-24											2	0	3	0	3	0	6	0	3	0	3	0	3	0	4	0	8	29	5	5	4	0	6	0	5	0	49—54	34	.660
1219	3-3	7	0	3	0	3	0	3	0	4	0	3	0	3	0	3	0	6	30	3	0	3	5	3	0	4	0	8	6									48—56	41	.788
																																						Average	Total	Aver
14 *	Total	7	14	3	0	3	0	3	0	4	0	3	0	3	0	3	0	6	188	3	0	3	11	3	1	4	30	8	76	5	7	4	35	4½	0	4½	12	56.21	374	.465
1233 *	3-15	4	0	4	0	3	0	3	0	3	0	6	0	3	0	3	0	3	0	4	0	8	0	5	0	4	0											49—53	0	.000
1234	5-7	3	0	3	0	5	3	16	1																													11—27	4	.211
1261 *	4-8	2	0	3	0	3	0	4	0	8	0	5	0	4	0	3	0	3	0	5	0	8	0	13	0													48—61	0	.000
1262	"	2	0	3	0	3	0	4	0	8	0	5	0	4	0	3	0	3	0	5	0	8	7	13	0	8	0											61—69	7	.108
1270	4-12	4	0	4	0	13	0	4	0	3	0	3	0	5	0	8	0	13	6	8	1																	57—65	7	.115
1271	"	4	0	4	0	13	0	4	0	3	0	3	0	5	0	8	0	13	0	8	0	8	0															65—78	0	.000
1272	"	4	0	4	0	13	0	4	0	3	0	3	0	5	0	8	0	13	0	8	0	8	0															65—78	0	.000
1281 *	4-28	1	0	4	0	4	0	3	0	3	0																											12—15	0	.000
1284 a	4-20	7	0	7	0	3	0	3	0	3	0	5	18	6	0	15	0	8	2	8	0																	57—65	20	.328
" b	"	7	0	7	0	3	0	3	1	3	0	5	10	6	0	15	8	8	0	8	0	4	0															65—69	19	.284
" c	"	7	0	7	0	3	0	3	0	3	0	5	13	6	0	15	11	8	2																			49—57	26	.490
" d	"	7	2	7	0	3	0	3	0	3	0	5	0																									23—28	2	.078
" e	"	7	0	7	0	3	0	3	0	3	0	5	0																									23—28	0	.000
" f	"	7	0	7	0	3	0	3	0																													17—20	0	.000
" g	"	7	0	7	0	3	0	3	0	3	1	5	16	6	0	15	0																					34—49	17	.410
" h	"	7	5	7	0																																	7—14	5	.476
																																						Average	Total	Aver
8 *	Total	7	7	7	0	3	0	3	1	3	1	5	57	6	0	15	19	8	4	8	0	4	0															36.56	89	.257

* Indicates females that were reared in confinement.

Egg-Laying Records of Individual Females of Phyllophaga Vandinei n. sp.

Exp. Number	Date	Days	Eggs	Days	Eggs	Days	Eggs	Days	Eggs	Days	Eggs	Days	Eggs	Days	Eggs	Days	Eggs	Days	Eggs	Days	Eggs	Lived Days	Laid Eggs	Eggs per Day
988	8-11	11	1	7	1	7	0															21—28	2	.082
1019 a	9-1	5	0	9	0	9	0															11—23	0	.000
" b	"	5	0	9	0	9	0															14—23	0	.000
" c	"	5	0	9	0	9	0	1	0	22	0											27—48	0	.000
" d	"	5	0	9	0	9	0	4	0	22	0											27—48	0	.000
" e	"	5	0	9	0																	5—14	0	.000
1020 a	8-26	3	0	2	0	3	0	3	0	6	0	7	0	5	0	1	0	21	0			33—54	0	.000
" b	"	3	0	2	0	3	0	3	0	6	0	7	0									17—24	0	.000
" c	"	3	0	2	0	3	0	3	0	6	0											11—17	0	.000
" d	"	3	2	2	0	3	1	3	1	6	0											11—17	4	.286
" e	"	3	0	2	0	3	0	3	0	6	0											11—17	0	.000
" f	"	3	0	2	0	3	0	3	0	6	0	7	0	5	0	5	0	20	0			34—54	0	.000
" g	"	3	0	2	0	3	0	3	0	6	4	7	0									17—24	4	.195
" h	"	3	0	2	0	3	0	3	0	6	1	7	5	3	1							24—27	7	.275
" i	"	3	1	2	2	3	0	3	0	6	0	7	0	3	0	2	0	5	0	20	0	34—54	3	.068
" j	"	3	0	2	0	3	6	3	0													8—11	0	.000
" k	"	3	0	2	0	3	0	3	0													8—11	0	.000
" l	"	3	0	2	0	3	0	3	0	6	0	7	5	3	0							24—27	5	.196
1032 a	9-3	3	0	3	0																	3—6	0	.000
" b	"	3	0	3	0	7	0	8	0													13—21	0	.000
" c	"	3	0	3	0	7	0	8	0	2	0	24	17									23—47	17	.486
" d	"	3	0	3	4																	3—6	4	.889
" e	"	3	0	3	0	7	0	8	6	2	0	2	0	20	0							25—45	6	.171
" f	"	3	0	3	0	7	0	8	0	2	0	2	0	22	2							25—47	2	.055
" g	"	3	0	3	0	7	0	8	0	2	0	2	0	22	0							25—47	0	.000
" h	"	3	0	3	0	7	0	8	0	4	0											21—25	0	.000
" i	"	3	0	3	0	7	5															6—13	5	.526
" j	"	3	0	3	0	7	0															6—13	0	000
" k	"	3	0	3	0	7	0															6—13	0	.000
" l	"	3	0	3	0	7	1															6—13	1	.121
1052 a	9-25	3	0	1	0	18	0	8	0	8	0	1	0	11	0	10	0	8	19	13	0	71—87	19	.236
" b	"	3	0	1	0	18	0	16	0	1	0	11	0	10	0	8	12	13	0	16	0	87-103	12	.126
" c	"	3	0	1	0	18	0	16	4	15	2											41—56	6	.124
" d	"	3	0	1	0	18	0	16	11	15	3	10	0	8	0	13	0					74—87	17	.210
" e	"	3	0	1	0																	3—7	0	.000
" f	"	3	0	1	0	18	0	16	10	15	15	10	2	8	0							66—74	27	.386
" g	"	3	0	4	0	18	0															7—25	0	.000
" h	"	3	0	4	0	18	0	16	5	15	1											41—56	6	.124
" i	"	3	0	4	0	18	0	16	0	15	0											41—56	0	.000
" j	"	3	0	4	0	18	0	16	3													25—41	3	.091
" k	"	3	0	4	0	18	0	20	30	11	0											45—56	30	.594
" m	"	3	1	4	0	18	0	20	12	11	0											45—56	12	.238
" n	"	3	0	4	0	18	7	20	0													25—45	7	.200
" o	"	3	0	4	0	18	0	20	0													25—45	0	.000
" p	"	3	0	4	0	18	0															7—25	0	.000
" q	"	3	0	4	0	17	0	3	0	18	7	21	0	8	0							66—74	7	.100
" r	"	3	0	4	0	17	0	3	0	18	23	21	0									15—66	23	.414

Exclusive of reared adults, a total of 75 females were confined singly for eggs, of which number 45 females laid a total of 713 eggs, or an average of 16 eggs each, while 30 females laid no eggs.

Average from the 45 females, .345 eggs per day, or 1 egg each 3 days.
Average from the 75 females, .204 eggs per day, or 1 egg each 5 days.

It is reasonable to believe that those females which did not lay eggs were old females, and were exhausted of eggs before confined. The confined females were collected in the field, and their age from date of first emergence could not therefore be determined. It is believed that the average from the forty females that laid eggs can be taken as nearly the correct or normal figure.

The average length of life of 45 females that laid eggs was 47 days (about one and one-half months); the average length of period of oviposition 11 days (about one and one-half weeks). (The duration of oviposition is taken as including the time between the recorded dates of laying of the first and last eggs in confinement.) As the environment of the beetles in the experimental jars was certainly quite different from that outdoors, it is possible that these figures would be materially lengthened in outdoor or natural conditions.

The greatest duration of the egg-laying period was 42 days (or six weeks), the female laying in that time only 39 eggs, or slightly under one egg per day. The egg-laying period of 25 out of the 45 females was less than one week in duration.

The female that lived the longest in confinement, 95 days (or thirteen and one-half weeks), laid only 12 eggs, all within three days. One female lived 59 days (or eight and one-half weeks) and laid no eggs, being fed, however, during the entire period.

The egg laying of adults is periodical. For instance, in the group of 14 females included in the numbers 1206 to 1219, inclusive, where the average length of life was 56 days, over half of the 188 eggs were laid within six days—between the 30th and 35th days of confinement. Again, in the group of eight females included in the numbers 1284*a* to 1284*h*, inclusive, where the average length of life was 36½ days, over three-fifths of all the 57 eggs were laid in the five days between the 27th and 32d days of confinement. There facts, merely as circumstancial evidence, would make it appear that about a month is required for mature eggs to form in the female uterus after copulation.

The largest number of eggs laid in a short space of time by a female was 35 (see No. 1209), laid in two days, or at a rate of 18 eggs per day.

The data obtained from the females confined "en masse" show that—a total of 1,406 females laid 1,560 eggs in an average period of 6.4 days. Or, reduced to the equivalents of the preceding table of averages:

Average from 60 per cent of females, .29 eggs per day, or 1 egg each 3½ days.
Average from all the females, .172 eggs per day, or 1 egg each 5¾ days.

INSECT PARASITISM.

The insects which prey upon this species are the same as those listed for the genus. Probably one of the more important ones is the predacious wireworm, *Pyrophorus luminosus* Ill., the exact value of which, however, as a control of the grub in the fields it is very difficult to ascertain, from the fact that, in digging or plowing, living wireworms are very rarely found adjacent to the grubs they have attacked.

Other important enemies of *vandinei*, in the more northern part of its range, are the two Tachinid flies which parasitize the adults.

As to the large Scoliid wasp, *Campsomeris dorsata* Fab., it has been found that on the island of Barbados the species, though commonly parasitizing and apparently preferring the Dynastid, *Ligyrus tumulosus* Burm., is occasionally found parasitizing a common Melolonthid, *Phytalus smithi* Arrow (18, p. 56). In Porto Rico this wasp is particularly abundant in the Guánica district, where it has been often found parasitizing *Ligyrus tumulosus* grubs. It is possible that it may rarely attack grubs of *Phyllophaga vandinei*: but to the present date none of the records of its attack of this species have been verified; and the fact is patent that, of many hundreds of grubs of *vandinei* examined by the writer, and many dozens reared in confinement, not one has ever been observed parasitized by egg or larva of this wasp. Dry grub remains have been examined attached to numbers of *Campsomeris* cocoons collected at Santa Rita, but none of them proved to be *vandinei*.

The Tachinid flies.—Two species of Tachinid fly, *Cryptomeigenia aurifacies* Walton (see Pl. VII, fig. 7) and *Eutrixoides jonesii* Walton, which have been previously discussed, are known to attack this species and *portoricensis* in the more humid parts of their habitats, and to do much to keep them in check in those localities. A rather large percentage of specimens of *vandinei* collected at Añasco, at the west end of the Island, have been found infested with the pupæ of *Cryptomeigenia*, and a far smaller number with *Eutrixoides*. Collections of pupæ have been made in April, May and September, but doubtless can be found throughout the year. The number of pupæ

found within one dead adult host varies from two to nine, usually four to six. Infested beetles that have died are always found in their burrows in the ground.

Work on the life-histories of the two species is in progress now, but has not yet been completed.

Neither species has been found to occur in the Guánica district, where the damage from *vandinei* is most acute. Attempts to introduce the flies at Santa Rita, using infested beetles taken there from Añasco, were not successful; and it seems probable that the flies do not thrive in a dry climate like that of the south coast.

Attacked by mites and nematodes.—In the experimental jars and boxes some difficulty was experienced in the rearing of eggs of *vandinei* because of attack by nematodes and mites, the latter apparently a species of *Tyroglyphus*. The following brief notes may serve as examples of the manner in which this loss of eggs occurred:

No. 1016.—August 25, eleven eggs, laid since August 17, were put into artificial cells at bottom of a jar. August 26, one egg destroyed, surrounded by a myriad of young nematodes. August 27, two more similarly destroyed. August 30, all the other eggs but four destroyed by the nematodes.

No. 1021.—August 26, fourteen eggs, laid August 18 to 21, were put into damp sifted earth at bottom of jar. August 27, one destroyed by nematodes and mites. August 29, two more destroyed. September 30, last two killed by mites, and being eaten by them.

The injury from the mites was not limited to the eggs, grubs in all instars often suffering badly, even dying, from their attack. The following notes give specific examples of mite injury to grubs:

No. 1049d.—January 28, a grub in second, molted about December 12, heavily infested with mites. February 17, grub died as result, without being able to molt.

No. 1049g.—January 18, a grub in second, molted about December 20, partly covered with mites on head, legs, and front of body. February 25, molted. June 25, sickly, with many mites. June 30, dead, eaten up by mites.

No. 1193.—May 3, grub preparing to pupate put into box. May 22, died before pupating; covered with mites.

No. 1216d.—May 15, grub in first, hatched May 15, has mites. June 2, injured by mites, and died molting to second.

No. 1309a.—June 18, grub hatched since yesterday put into box. July 29, half covered with mites, which prevent its growth. August 9, sickly, with many mites. August 14, died without molting to second.

Eggs devoured by wireworm and Staphylinid larva.—Occasional loss of eggs was experienced in experimental jars from wireworms (*Monocrepidius* sp., undetermined) and from larvæ of a small Staphylinid beetle, introduced into the earth with manure. The following extracts from notes give specific cases:

No. 1032.—September 24, six eggs, laid since September 17, put over damp earth in a box. September 25, two eggs missing, and a wireworm present, eating a third.

No. 986.—August 14, out of nine eggs, laid August 9–11, placed in artificial cells in earth, two were destroyed by Staphylinid larvæ, which occupied the cavities where eggs had been.

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EXPLANATION OF PLATES.

Plate II.

Fig. 1.—Banana tree stripped of foliage by May-beetles, chiefly by *Phyllophaga vandinei* n. sp.
Fig. 2.—Leaf of a coconut palm injured by the feeding of adults of *Phyllophaga portoricensis* n. sp.
Fig. 3.—Salcilla tree (*Schrankia portoricensis*), a wild species abundant in the Guánica district and whose foliage is much relished by adults of *P. vandinei*; adaptable for use in collecting the beetles in large numbers by shaking.
Fig. 4.—A bushel of adults of *P. vandinei* collected in one evening by nine boys in a cane field at Santa Rita, near Guánica.

Plate III.

Fig. 1.—*Phyllophaga vandinei* n. sp., eggs lying over soil, x 2 (the elongate egg marked with an "x" is that of *Pyrophorus luminosus* Illiger, an Elaterid whose larva is predaceous on white-grubs).
Fig. 2.—*Phyllophaga vandinei* n. sp. grubs just hatched from eggs, x 3.
Fig. 3.—*Phyllophaga vandinei* n. sp. grubs at end of first instar, x 2.
Fig. 4.—*Phyllophaga vandinei* n. sp. grub at end of second instar, x 2.
Fig. 5.—*Phyllophaga vandinei* n. sp. grub in act of molting to third instar, x 5.
Fig. 6.—*Phyllophaga vandinei* n. sp. grub at beginning of the third instar, x 2.
Fig. 7.—*Phyllophaga vandinei* n. sp. mature grub (at end of third instar), x 2.
Fig. 8.—*Phyllophaga vandinei* n. sp. prepupa (grub about to pupate), x 2.
Fig. 9.—*Phyllophaga vandinei* n. sp. pupa, side view, showing shed larval skin, x 2.
Fig. 10.—*Phyllophaga vandinei* n. sp. pupa at point of issuing of adult, x 2.

Plate IV.

Fig. 1.—*Phyllophaga vandinei* n. sp., pupa, ventral view, x 2.
Fig. 2.—*Phyllophaga vandinei* n. sp. pupa, dorsal view, x 2.
Fig. 3.—*Phyllophaga vandinei* n. sp. male adult, x 2.
Fig. 4.—*Phyllophaga portoricensis* n. sp., female adult, x 2.
Fig. 5.—*Phyllophaga portoricensis* n. sp. male adult, x 2.
Fig. 6.—*Phyllophaga vandinei* n. sp. adult just issued from pupa, x 2.
Fig. 7.—*Phyllophaga vandinei*, n. sp. adult attacked by *Meterrhizium*, dorsal view, x 2.
Fig. 8.—*Phyllophaga vandinei* n. sp. same, side view, x 2.
Fig. 9.—*Phyllophaga vandinei* n. sp. larva infested with *Metarrhizium*, x 2.

Plate V.

Fig. 1.—*Phyllophaga vandinei* n. sp. heads of grubs in first instar, x 10.
Fig. 2.—*Phyllophaga vandinei* n. sp. head of a grub in second instar, x 10.

Fig. 3.—*Phyllophaga vandinei* n. sp. head of a grub in third instar, x 10.
Fig. 4.—*Phyllophaga guanicana* n. sp., male genitalia, x 6 (with mm. scale).
Fig. 5.—*Phyllophaga citri* n. sp., male genitalia, x 6.
Fig. 6.—*Phyllophaga vandinei* n. sp., male genitalia, x 6.
Fig. 7.—*Phyllophaga portoricensis* n. sp., male genitalia, x 6.
Fig. 8.—*Phyllophaga citri* n. sp., female genitalia, x 5½ (ventral view).
Fig. 9.—*Phyllophaga portoricensis* n. sp., egg in pit made by the ovipositor, x 6.
Fig. 10.—*Phyllophaga portoricensis*, female genitalia, x 5½ (ventral view).

Plate VI

Fig. 1.—Black birds (*Holoquiscalus brachypterus*) following a plow in cane field at Santa Rita to pick up white grubs.
Fig. 2.—*Phyllophaga guanicana* n. sp., egg lying over soil, x 2.
Fig. 3.—*Phyllophaga guanicana* n. sp., swollen eggs in the natural pits, x 6.
Fig. 4.—*Phyllophaga guanicana* n. sp., grub at end of second instar, x 2.
Fig. 5.—*Phyllophaga guanicana* n. sp., mature grub (end of third instar), x 2.
Fig. 6.—*Phyllophaga guanicana* n. sp., male adult, x 2.
Fig. 7.—*Phyllophaga guanicana* n. sp., female adult, x 2.
Fig. 8.—*Phyllophaga citri n.* sp., male adult, x 2.
Fig. 9.—*Phyllophaga citri* n. sp., female adult, x 2.

Plate VII.

Fig. 1.—*Phytalus insularis* n. sp., eggs lying over soil, x 3.
Fig. 2.—*Phytalus insularis* n. sp., grubs at end of third instar, x 3.
Fig. 3.—*Phytalus insularis* n. sp., pair of adults, x 3.
Fig. 4.—*Phytalus insularis* n. sp., head of adult below that of *Phyllophaga vandinei* to show comparative size, x 6.
Fig. 5.—*Phytalus insularis* n. sp., anal aspect of female adult (with scale in millimeters to show size), x 6.
Fig. 6.—*Phytalus insularis* n. sp. anal aspect of male adult, x 6.
Fig. 7.—*Cryptomeigenia aurifacies* Walton, adult (right) and pupal case (left), x 3.
Fig. 8.—*Tiphia inornata* Say, adult male at right, adult female at left over the cocoon.

Plate VIII.

Life-cycles of individual females of *Phyllophaga vandinei* n. sp. in Porto Rico.

Plate IX.

Egg-laying records of individual females of *Phyllophaga vandinei* n. sp.

Plate II.—Porto Rican Melolonthids.

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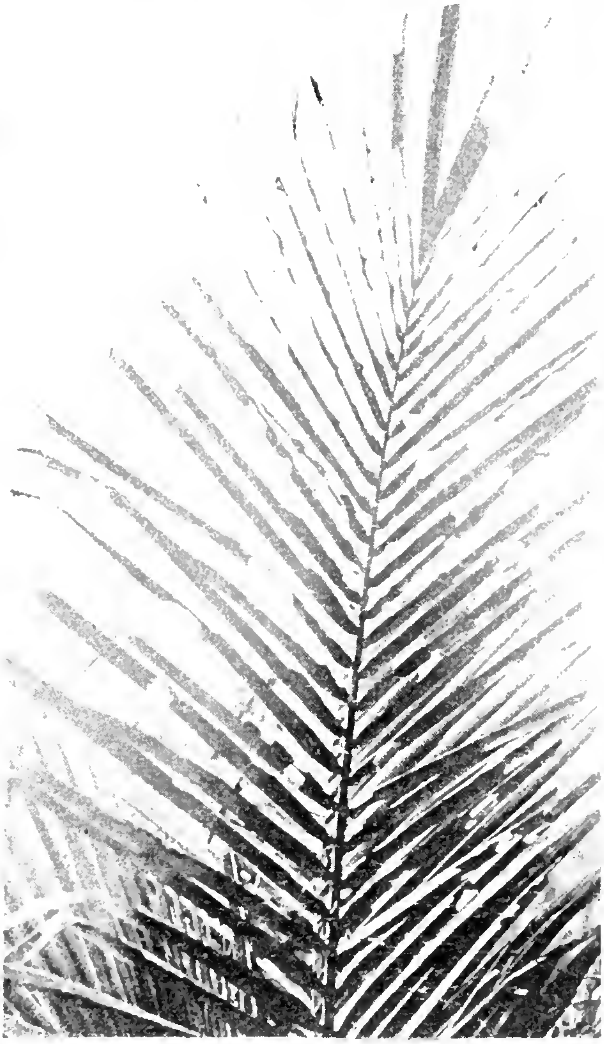

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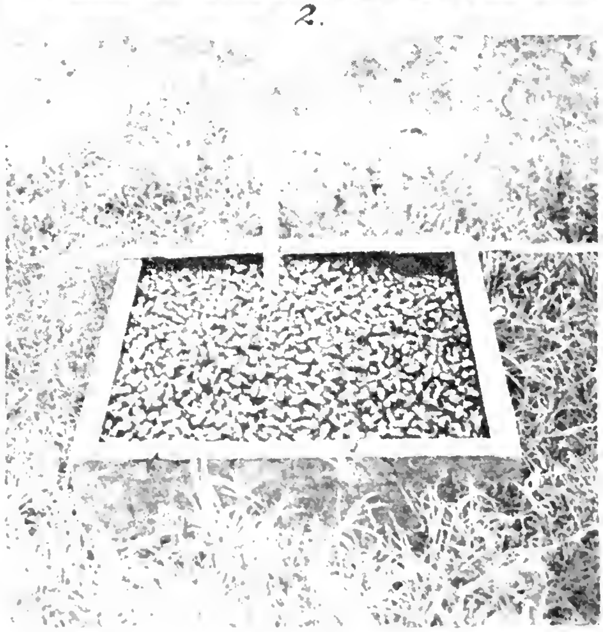

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Plate III.—Porto Rican Melolonthids.

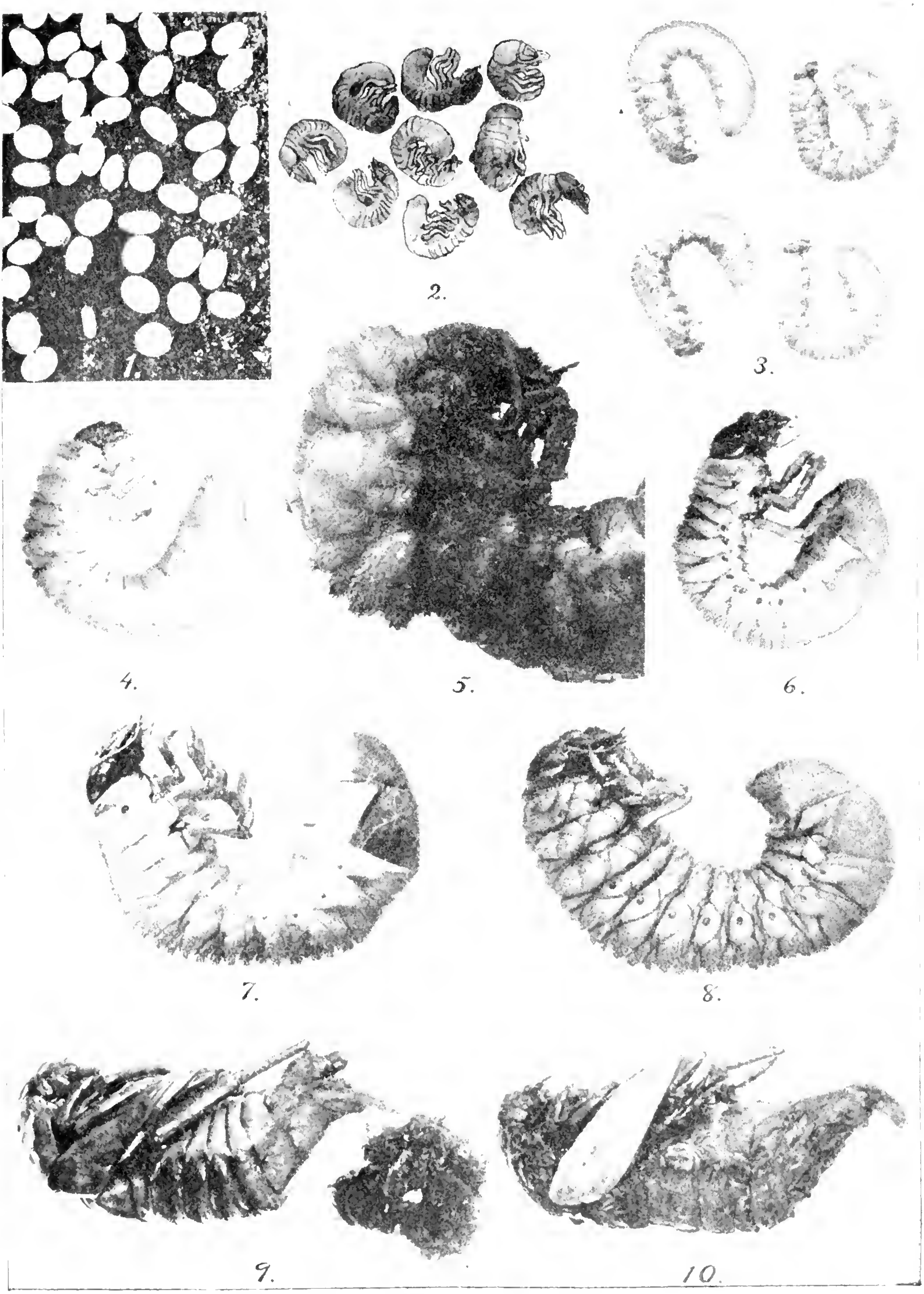


Plate IV.—Porto Rican Melolonthids.

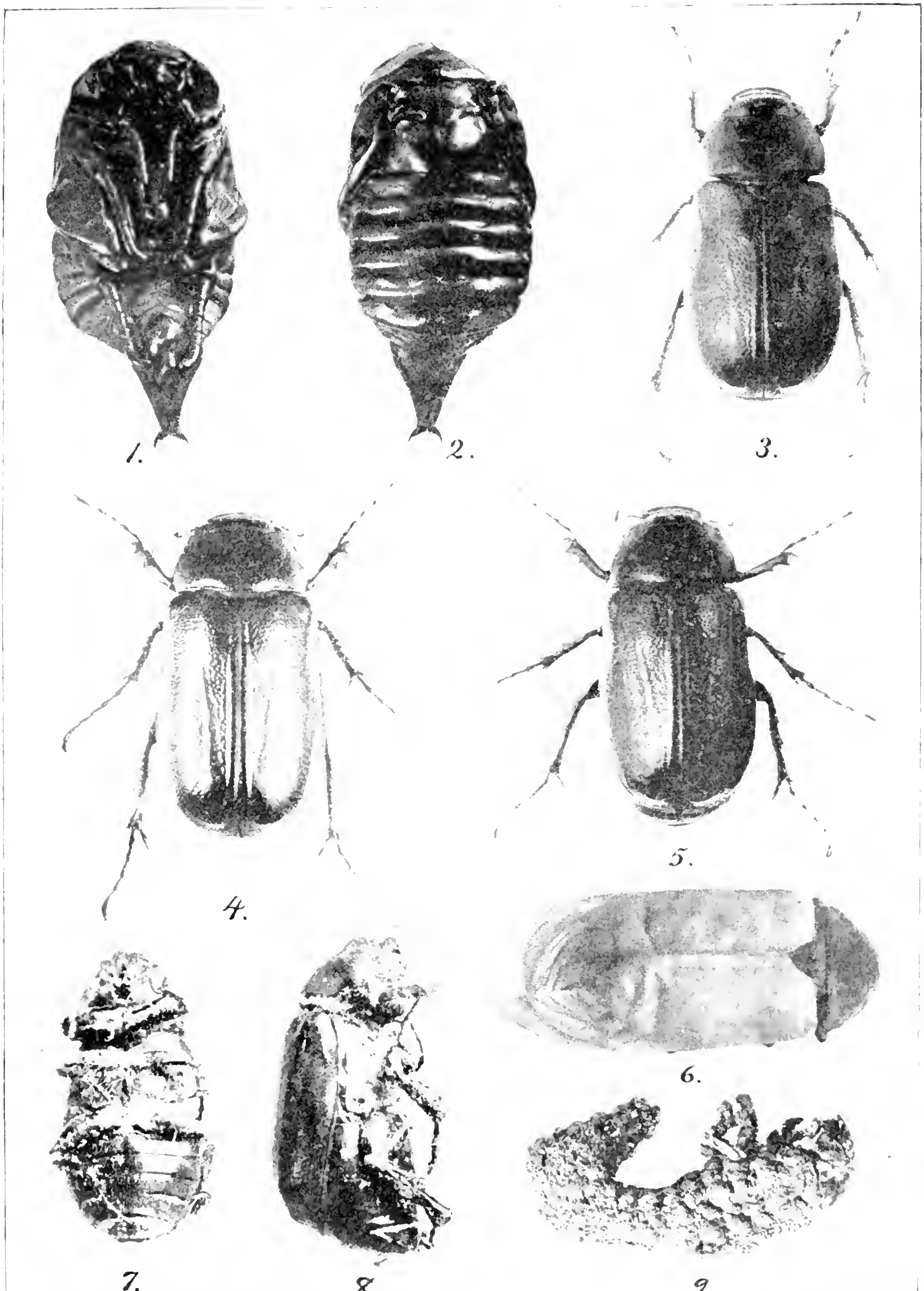


Plate V.—Porto Rican Melolonthids.

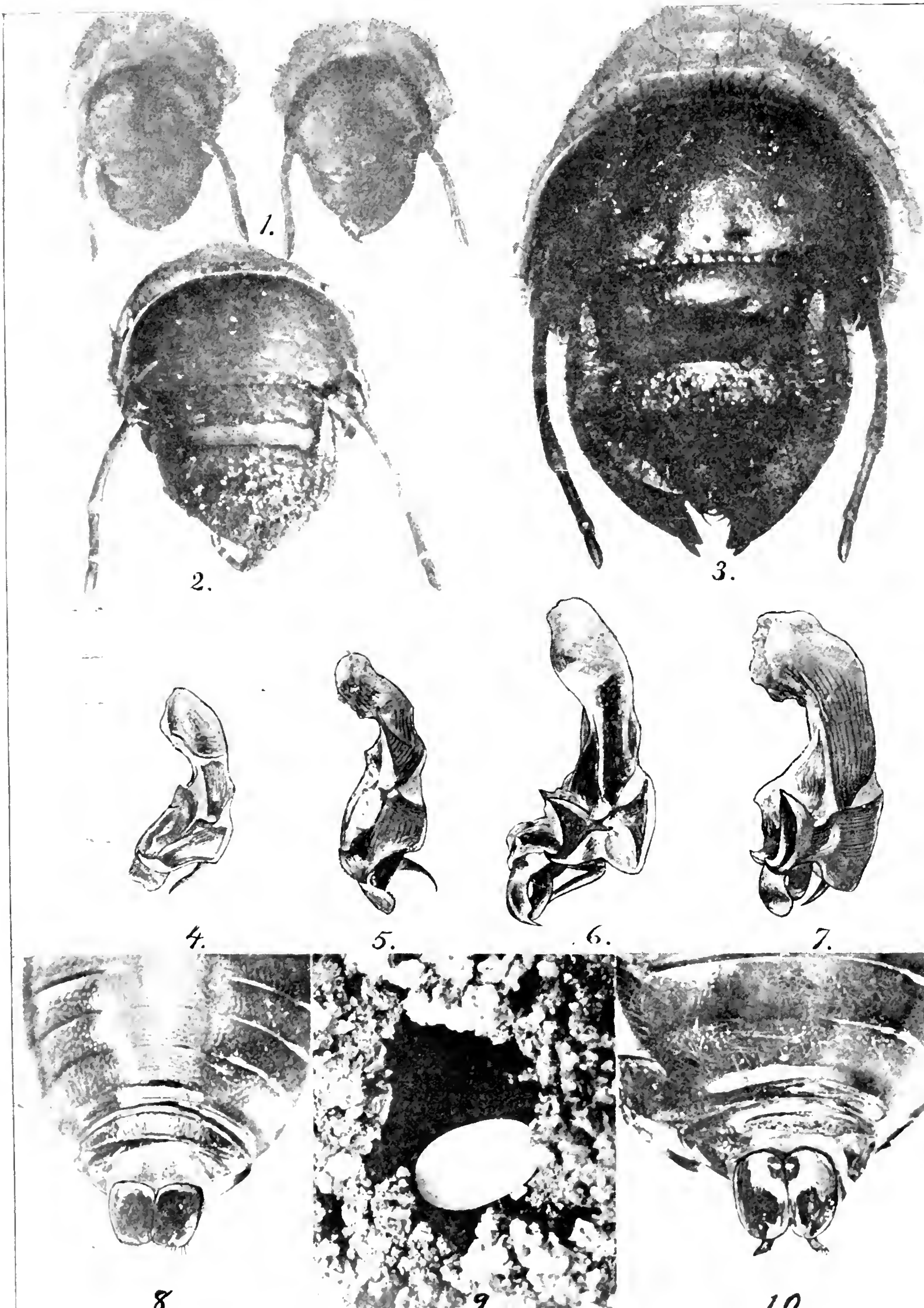


Plate VI.—Porto Rican Melolonthids.

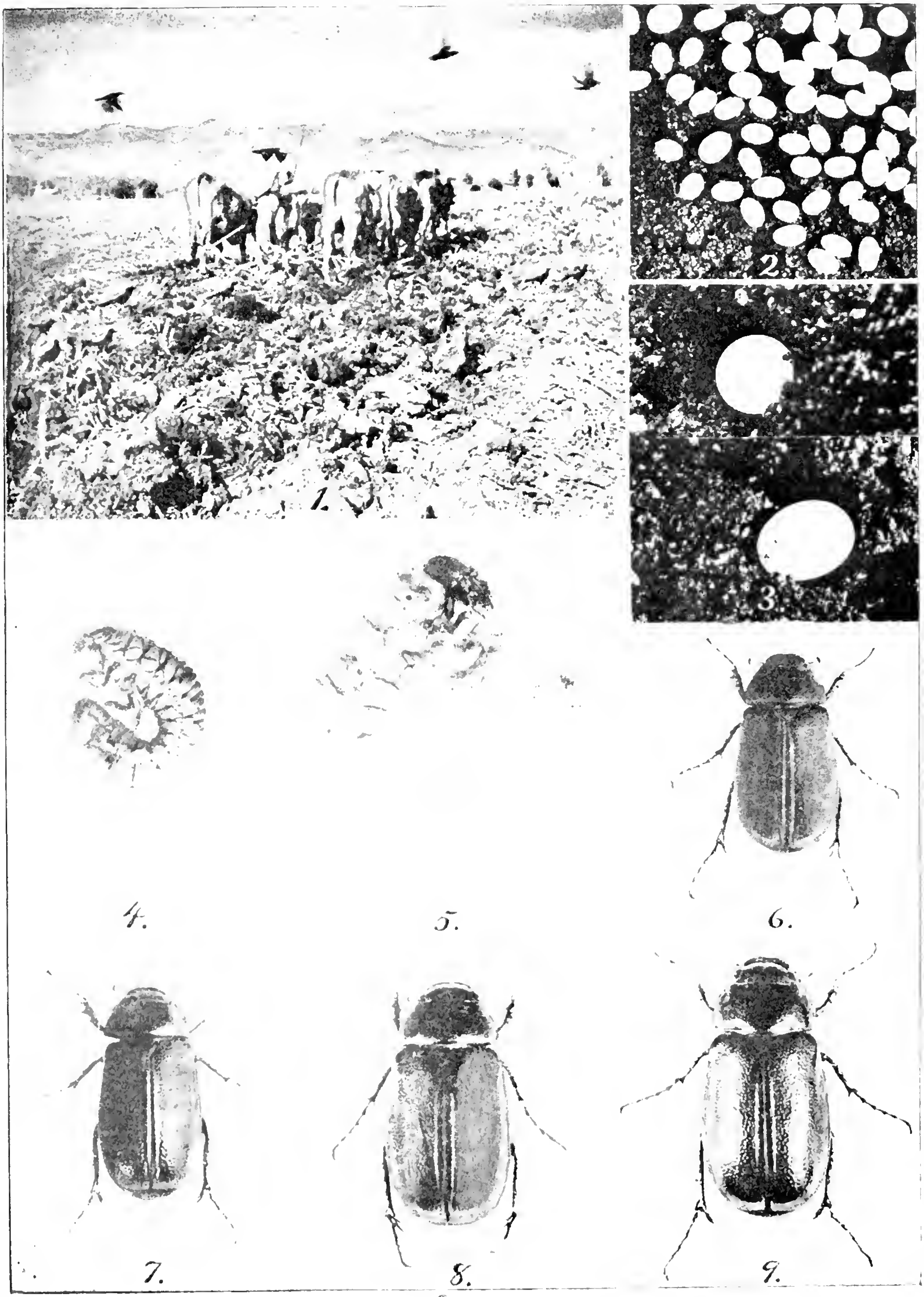


Plate VII.—Porto Rican Melolonthids.

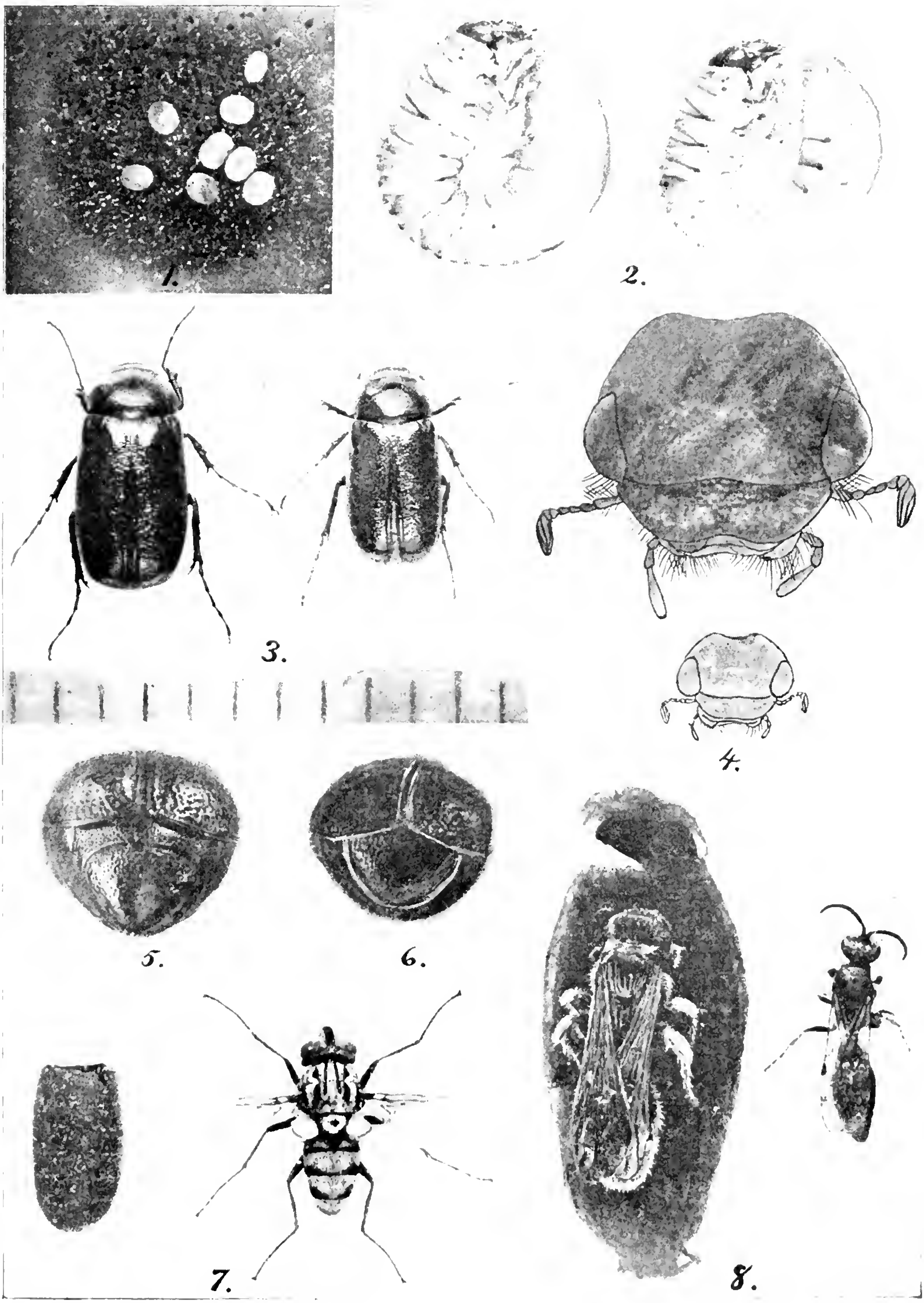


Plate VIII.—Life-Cycles of Individual Females of Phyllophaga Vandinei n. sp. in Porto Rico.

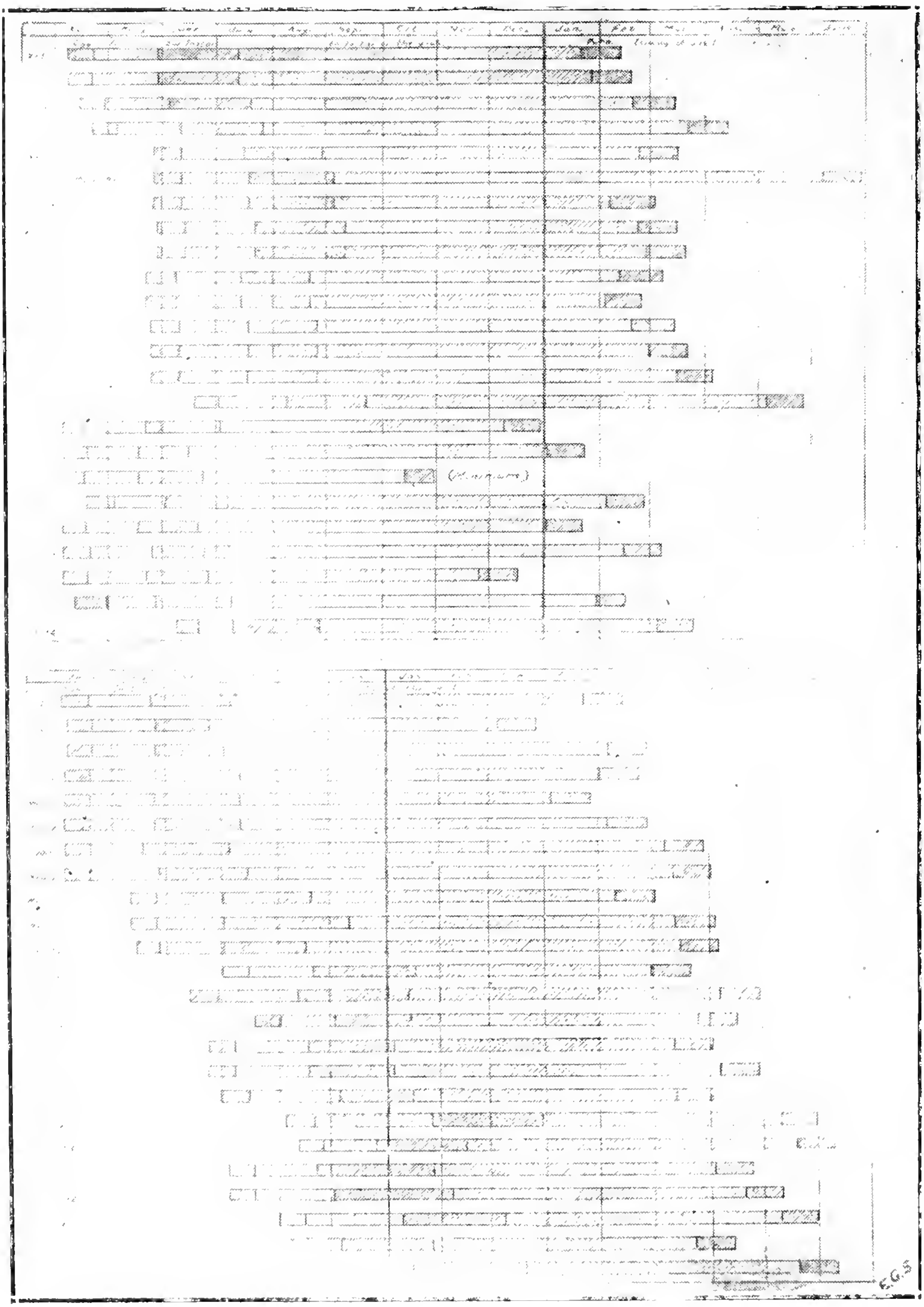
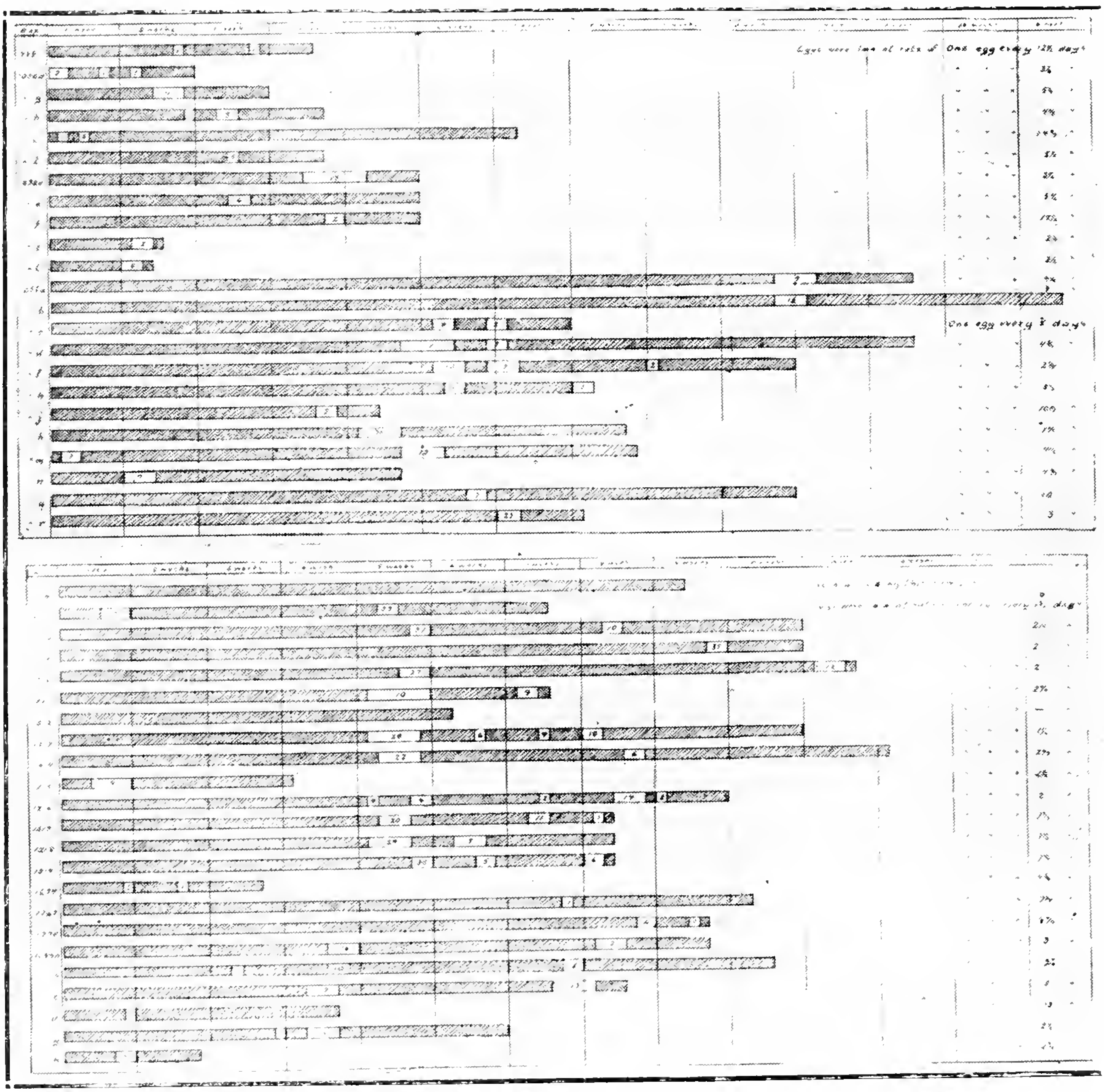


Plate IX.—Egg-Laying Records of Individual Females of Phyllophaga Vandinei.



DISEASES OF VEGETABLE AND GARDEN CROPS.

By JOHN A. STEVENSON, Pathologist, Insular Experiment Station.

In making inquiries among the agriculturists of the Island as to why the growing of the common northern vegetables was not taken up for at least a home supply, the reply has universally been that all such attempts ended in failure. At times with the weather favoring one crop would be secured, but a second was apparently impossible. While it was realized that tropical weather conditions would not be conducive to the best growth of northern vegetables, still it was difficult to see why such complete failures resulted. Consequently a close watch was kept on the various trial plots at the Station and in so far as possible upon gardens in other parts of the Island; in particular the public gardens and those maintained in connected with the normal school at Río Piedras.

As a result observations have been made upon a very large number of fungi causing diseases of the various garden crops. In some cases these have attacked with such virulence as to readily explain the numerous failures reported, especially those with cucumbers and tomatos. Practically all of the troubles so far observed are those of common occurrence in continental America and have all doubtless been introduced with the seed or other plant parts. Many interesting questions have arisen in the work with these diseases especially as regards their dependence upon weather conditions (temperature and humidity), their relation to insects as spore carriers, and above all their modes of attack. Soil and cultural conditions have likewise played an important part. Some of these points will be touched upon in the separate account of the diseases to follow, but others must be deferred until more detailed investigations can be carried out.

Some previous work has been done on the diseases of vegetables in Porto Rico, but with the exception of short notes of occurrence in reports of the Mayagüez Experiment Station, there are no published records. In Bulletin 7 of that Station, issued in 1906, reference is made, in connection with cultural directions for the various vegetables, to certain of the more common diseases and some suggestions for control are made. Certain ones are definitely reported as found in Porto Rico, but for the most part it is impossible to tell whether a given disease is so reported or whether the note is merely

a warning against a trouble that may appear. In the following account such data as the records of this office afford are reported, including for the purpose of completeness other published notes.

Very little has been attempted as yet in the way of control of the fungus diseases here given. Such experiments as time has permitted will be touched upon in the individual discussions which follow. It may be noted, however, that these have been rather uniformly unsuccessful and that methods other than those commonly advised for northern conditions must be tried.

Notes and observations on the various diseases found or reported follow, arranged topically under the various host plants.

Asparagus (*Asparagus officinalis*).

In so far as noted this crop has not been grown successfully, although there have been reports of fair yields. The few plants seen had produced a fair growth of top but no edible shoots. An undetermined imperfect fungus, causing black lesions on the stems, has been found on old or dying plants. The rust (*Puccinia asparagi*) does not occur.

Beans (*Phaseolus* spp.).

Two plantings of this crop were made at the Insular Station, one in February and the other in May on separate pieces of land. It is of interest to note that the diseases occurring on the first planting were lacking or of minor importance on the second; a state of affairs doubtless to be attributed in part to weather conditions and in part to the use of seed from various sources infected with different diseases.

As will be noted below there was a marked varietal resistance to the different diseases and a solution of the problem seems most probable through the use of resistant varieties. Native types already exist which thrive very well, and doubtless others will be found in the course of the experimental work which will be even more thrifty and disease resistant.

Anthracose, Spotting of Pods (*Colletotrichum lindemuthianum* [Sacc. & Magn] Scribner).—This well-known disease has been very prevalent and forms one of the greatest obstacles to successful bean culture in Porto Rico. It has been commonly observed on green beans of local varieties offered for sale in the native shops, as well as on the northern types tried experimentally.

The pods, leaves, and stems were subject to attack. On the leaves the disease was noted as irregular, red-brown spots or more com-

monly as lesions along the midrib and principal veins. Susceptible varieties lost a large percentage of their leaves. Similar lesions also occurred on the stems and petioles, several such often uniting so as to involve practically their entire length. Young plants were in some cases completely girdled, resulting in speedy death, and in other instances they were so seriously weakened that little growth was made. On the pods very characteristic spots occurred. These appeared first as circular dark-brown areas, soon becoming sunken, and often coalescing to form irregular cankers. In each of these spots there was an abundant production of conidia (reproductive bodies) occurring in the form of numerous pink masses, so that at this stage the spots had a decided pink color. The fungus grows from these spots into the seeds, where it remains dormant until germination occurs, when it attacks the young plant. The necessity of selecting seed from disease-free pods will be apparent, since there is no method of destroying the fungus present without destroying at the same time the vitality of the seed.

As soon as the presence of anthracnose was noted spraying tests with Bordeaux mixture were initiated. Two applications were made. While it is impossible to draw definite conclusions from the results of one year's tests on a small plot, it seems apparent that spraying, with Bordeaux at least, is not effective, a conclusion which workers in other regions have also reached. Here as elsewhere the solution of the problem lies in the production of resistant varieties, a matter which has already been taken up by the plant breeder with excellent prospects of success. A black Venezuelan bean has so far given excellent results, and if it maintains its freedom from disease will be very satisfactory.

The first trials included the following varieties arranged here in their order of susceptibility as indicated by one season's tests in short parallel rows:

	Per cent of pods spotted.
Saddle black wax	42
Burpees round yellow, six weeks bush	34
Improved black wax	32
Hendesons bountiful bush	21
Extra early refugee	10
Early bountiful bush	8
Early red valentine bush	7
Curry's golden wax rust proof	5

This arrangement is based upon observations of the severity of infection on leaves and stems and upon counts of the pods, classifying them as free of spots, spotted and rejected. This count seemed

to show some benefit from the spraying, but the plantings were not large enough to give conclusive evidence. It is doubtful whether spraying will prove effective enough to pay for the additional expense. It must be noted with regard to varietal resistance that seed infection, a most important point, was not considered.

Later in the season a second crop of beans was grown on a neighboring plot of ground. The varieties were refugee, 1000-1 (both northern types), a black Venezuelan bean, and the native red bean. Only the slightest trace of anthracnose appeared, and this on the "refugee." Whether this freedom from disease was attributable to weather conditions, to clean seed or to varietal resistance was not apparent. Further tests are necessary.

DOWNY MILDEW.—A virulent disease, caused by a fungus of the *Phycomycetes* or alga-like fungi, attacked the refugee and 1000-1 beans of the second planting. The Venezuelan black wax and native red types in adjacent parallel rows were unaffected. The trouble appeared over night practically, and within a week had destroyed large portions of the plantings.

A plant once attacked rapidly succumbed, the leaves wilting and drooping in such a way as to suggest root troubles, but examination of early stages revealed healthy stems and roots, the tops being attacked first. The withering and consequent death of an infected plant, however, occurred very speedily. At times single plants only were attacked, but more commonly entire sections of a row up to eight or ten feet in length were killed, the disease spreading rapidly from the original point of infection. The most striking feature of this disease was the fungus growth on the pods occurring as flocculent (fluffy) white masses of mycelium obscuring the upper half of, or even at times the entire length of, the pod. Attacked pods were destroyed by soft rot.

The damage that this disease would be capable of, if bean growing were attempted on a commercial scale, was well illustrated by the fate of a peck of the refugee variety which was left for several days in the picking basket. When examined the entire lot had been matted together by the mycelial masses of the fungus and completely soft-rotted. Shipping this variety at least would have been a decided failure.

Time has not permitted any further studies of this disease. Hence the systematic position of the fungus involved has not been determined. It is not *Phytophora phaseoli* Thaxter, which fungus, however, has been reported (5)[1] on lima beans in Porto Rico.

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[1] Reference is made by number to "Literature cited," p. 117.

Gray Leaf-Spot (*Isariopsis griseola* Sacc.)—On the first planting spots due to this fungus were rare, but on the second were fairly abundant on the northern varieties. The black Venezuelan remained free. A native variety of the red kidney type was noted, in which the entire planting was spotted to such an extent as to cause a heavy dropping of leaves and consequent weakening of the plants. It is a common disease in native plantings. It can doubtless be controlled by Bordeaux mixture.

This disease was characterized by irregular, brownish gray to gray spots on the leaves up to half an inch in diameter. The spots differed from those due to *Cercospora* in that they were duller in color and lacked the definite red-brown angular margin. The fungus fruited freely in the center of the spots and appeared under a hand lens as numerous erect, rather compact, black clusters of conidiophores or conidia-bearing threads.

Leaf Spots (*Cercospora* spp.)—At least one other type of leaf spot occurred. The one commonly found and due to *Cercospora canescens* Ell. & Martin was collected on varieties of *Phaseolus vulgaris* (common bean), *Dolichos lablab*, and *Phaseolus lunatus* (lima bean). The spots due to this fungus were more or less angular, up to one-fourth inch in diameter, gray with a reddish brown definite margin, and their appearance was the same on both sides of the leaf. A specimen of *Cercospora cruenta* Sacc. collected on bean in Porto Rico is in the herbarium of the New York Botanical Garden. *Dimerium grammodes* (Kuntze) Gar. is reported on *Phaseolus lunatus* by Garman (9).

Powdery Mildew (*Erysiphe polygoni* DC?).—A powdery mildew appeared on the leaves of several of the varieties after the crop had been gathered and the plants were past maturity. Only unsprayed portions of the rows were attacked. It is of very minor importance since only old, unsprayed plants were found subject to it. The determination can be only provisional since the imperfect or *Oidium* stage only was found.

Crown Rot (*Fusarium* sp.)—A crown rot or damping-off was noted to a very limited extent attacking the native red variety. Sunken lesions occurred on young plants at the ground level and extended for an inch or two along the stem, accompanied by a scanty production of white mycelium of a *Fusarium* sp. This was later noted on northern varieties, attacking young plants at various stages up to six inches in height, in some cases isolated plants only, in others accounting for several plants in a group or even a dozen or

more. The *Fusarium* found is apparently the same as causes a "damping-off" of tomato and eggplant seedlings.

BLIGHT (*Bacterium phaseoli* Sm.).—While this disease has not been definitely identified by exact methods, there can be but little doubt of its presence on northern varieties, but fortunately to a very limited extent only.

RUST (*Uromyces appendiculatus* [P.] Lk.)—The bean rust is known to occur on the Island, but has not been collected on the cultivated bean at this Station, although of common occurrence on several of the wild legumes (*Phaseolus adenanthus*, *Vigna repens*), etc. It forms very small, but numerous brown powdery eruptions on leaves and pods. It is not of sufficient importance to warrant control measures.

ROOT ROT OR WILT.—As many as four types of root rot or wilt are reported (5, 1). *Cercosporium* (?) *beticola* is given as the possible cause of one form. No further notes are given. This type of disease has not been observed during the present investigations.

BEET (*Beta vulgaris*).

The leaf spot (*Cercospora beticola* Sacc.) has been the only disease so far observed on this host. The death of mature leaves was somewhat hastened, but no further damage resulted. The spots were numerous, of the same appearance on both sides of the leaf, circular, brown at first, but later dull gray to dirty white, with definite red-brown margins. The Swiss chard (*Beta vulgaris* var.) was also attacked, whenever the leaves were allowed to come to maturity.

CABBAGE (*Brassica oleracea*).

Cabbage remained comparatively free of disease, although not making a very satisfactory growth. A soft, putrid, bacterial rot destroyed individual plants which had been injured in cultivating. Diseases due to *Pseudomonas campestris*, *Plasmodiophora brassicae*, *Peronospora parasitica*, and *Macrosporium brassicae* are mentioned by Henricksen (5), but are not definitely reported as found in Porto Rico.

CELERY (*Apium graveolens*).

Celery was slightly attacked by rootknot (*Heterodera radicicola*), which is described in detail later. Leaf spot due to *Septoria petroselini* Desm. was not found.

Cassava (*Manihot utilissima*).

Withertip (*Gloeosporium manihot* Earle).—In one locality a sweet (non-poisonous) variety of cassava was suffering severely from die back induced apparently by poor soil, and prolonged drouth, aided by the fungus in question. There was a characteristic withering and dying of the leaves which remained hanging at the tips of the twigs. The twigs and even the branches died back for a considerable distance, at times nearly to the ground level. Examination of the underground portions of the plants revealed no indications of disease. On the dead twigs the fungus formed small black fruiting pustules. Under favorable conditions this disease probably will give no trouble, though removal of diseased portions and cultivation should suffice to check it if it should by any chance get a start.

Leaf Spot (*Cercospora henningsii* Allesch.)—The characteristic leaf spots due to this fungus are common but of no great importance. They are angular, small (seldom over one-eighth inch in diameter), and dull white or gray in color, with a definite reddish-brown margin.

Rust (*Uromyces janiphae* [Wint.] Arthur.)—Not common, producing brown, powdery pustules on the under sides of the leaves. A root rot has also been reported (8) on this host.

Chayote (*Sechium edule*).

The chayote is very subject to one or more leaf diseases which very often completely destroy the plant, frequently before any fruit has been produced. Spraying with Bordeaux mixture has not given satisfactory results in so far as observations have been made, nor do published records report any success along this line (5).

Miss Young (7) describes one type of leaf spot due to *Phyllosticta Sechii*. The spots caused by this fungus are said to be amphigenous, more or less irregular, often confluent, varying in size from two to twelve millimeters and dull white in color. Minute dark brown or black pycnidia are produced in the center of the spots on the upper surface of the leaves.

A second and much more virulent type of leaf spot occurs. This is due to an apparently undescribed species of *Cercospora* or preferably *Helminthosporium*. The spots are angular, up to ten millimeters in diameter, dull brown above, lighter below, sometimes becoming a dull white at the center in old spots, margins definite, fruiting on both surfaces. The leaf area between the numerous spots speedily dies and the leaf withers and drops. This disease presents

a very serious obstacle to the successful culture of the chayote. All of our collections of leaf spot on this host have been of this latter type, pycnidia of *Phyllosticta* being found in only one very old spot, making it appear probable that the *Phyllosticta* is but secondary when present at all.

A root rot has been reported by some growers, but no data has been secured.

CORN (*Zea mays*).

Both the rust and smut were observed, the latter less commonly. The rust *Uredo pallida* Diet and Holw.) attacked the older and lower leaves, generally at a time when the ears were nearly mature so that little damage could be attributed to it. It appeared as numerous small brown pustules on the under side of the leaves.

The smut (*Ustilago zeae* [Beck] Ung.) attacked all parts of the plant, distorting or destroying them, and forming irregular masses covered by a white membrane, which broke away, liberating the black, powdery, spore mass. It is of no importance in Porto Rico as yet.

A third disease occurred quite commonly, but is of no economic importance as yet. This is manifested as numerous black, carbonous slightly raised spots on the leaves (both surfaces) and leaf sheaths in which the spore-bearing bodies are produced. Each spot is surrounded by a yellow or brown circle of dead tissue. The death of old or basal leaves is hastened, especially when the rust is also present as is usually the case. The fungus is *Phyllachora graminis* (Pers.) Fuckel.

COWPEA (*Vigna unguiculata*).

This legume has been used in some gardens between crops to improve the soil. Certain varieties thrive very well and their increased use is recommended. The iron variety is especially good for growing in this connection since it is not subject to nematodes, and in so far as observed does well under Porto Rican conditions. Other varieties are cultivated to some extent under the name of "frijoles" as food plants. Most of these latter types are, however, very subject to root-knot and proper precautions must be taken to avoid this trouble.

LEAF SPOT (*Cercospora vignae* Racib.)—This leaf spot as mentioned in a previous report (10) caused defoliation of an unknown variety of cowpea (not the iron) grown at the Station. The spots were numerous, circular, up to one centimeter in diameter, reddish brown in color, with distinct margins, and soon confluent, causing the death of the leaf.

Gray Leaf Spot (*Cercospora cruenta* Sacc.)—This leaf spot was found on one of the native edible seeded varieties, causing a serious weakening of the plants and partial defoliation. The diseased areas were angular to indefinite, three to eight millimeters in diameter at first, but rapidly coalescing, a dirty gray in color below, due to the copious production of conidia and conidiophores and yellowish or chlorotic above, becoming dull rust red. Would doubtless be controlled by Bordeaux or other fungicide.

On the iron cowpea a powdery mildew (*Erysiphe polygoni* DC?) was noted in several instances, but causing little harm. The *Oidium* stage only of the fungus was present.

Cucumber (*Cucumis sativus*).

Attempts to grow cucumbers in Porto Rico have been particularly disastrous. In some instances a splendid first crop has been obtained, but the second almost invariably fell prey to disease. A similar state of affairs occurred in the Station trials. The cause was largely the disease known as downy mildew and described below. Successful cucumber culture will depend upon its control.

Downy Mildew (*Pseudoperonospora cubensis* [B & C] Clinton.)—This disease was characterized by indefinite yellow spots on the leaves, which under the humid conditions existing here were so numerous or so rapidly coalesced that the death of the leaves quickly resulted. The superficial growth of the fungus itself could be seen as a delicate grayish purple layer on the under side of the leaves. The older leaves were attacked first and the disease progressed with the growth of the vines, usually three to four leaves behind the growing point. In wet weather, however, the leaves were attacked before they were completely unfolded, and in the second planting the cotyledons (seed-leaves) were attacked and destroyed before the second leaf had completely unfolded.

The mildew appeared on the first planting when the vines were about a foot long and had developed from four to seven leaves. Bordeaux mixture at a strength of 3–3–50 was immediately applied and additional applications made at weekly intervals until March 2, or eleven sprayings in all. As far as it was possible to observe spraying was without practicable results, except that aphids developed unchecked by fungus (*Acrostalagmus albus* ?). The disease progressed in the same degree upon sprayed plants and checks. Marketable cucumbers were secured for a time, but the disease finally gained the upper hand and the few fruit set after that time were small and misshapen.

Even worse results were obtained with the second crop planted in the same beds as the first. As noted the disease attacked the plants almost as soon as the first leaf was formed, although the first spraying had already been given. In all nine sprayings of Bordeaux (3-3-50) were made at three to four-day intervals. Practically no salable fruits were produced, the vines making little growth after the first few weeks.

One peculiar circumstance was noted after the beds were abandoned. Certain of the plants which had not been killed outright made considerable new growth, free of disease, and even produced normal fruit after the weeds had grown up around them, in spite of rather heavy rains. This circumstance suggests that infection occurs from the soil. Another year it is proposed to experiment with mulching and the training of the vines off the ground, since it is apparent that spraying is ineffective under Porto Rican conditions.

This disease has been reported as occurring upon various other wild and cultivated members of the cucumber family, but except for the melon no other hosts have as yet been found. Species examined have been:

Luffa cylindrica	Esponja.
Momordica charantia	Cundeamor.
Sechium edule	Chayote.
Lagenaria leucantha	Pipe gourd.
Cucurbita pepo	Calabazo, squash.

Anthracnose.—Ripe cucumber fruits and particularly the nubbins exposed to the sun on the nearly leafless, mildew-infected vines were attacked by anthracnose (*Colletotrichum lagenarium* [Pers.] E. & H.). The black fruiting spots of the fungus occurred in more or less circular sunken spots on the exposed surface and also on the indefinite dull white corky areas due primarily to sunburn. Various other saprophytic fungi were also present in such cases.

A fungus apparently referable to *Phyllosticta cucurbitacearum* Sacc. was found under the same conditions as the anthracnose fungus. In this case the grayish or dirty white irregular areas were dotted with the minute black pycnidia (fruiting bodies).

Neither the fungus nor bacterial wilt nor any form of damping off were observed.

Eggplant (*Solanum melongena*).

As was the case with the beans, one serious disease attacked the first planting and another quite distinct, the second. It was not possible to determine from the data of one season whether this was

due to weather, varietal differences, infected seed, or to a combination of various causes.

ANTHRACNOSE (*Gloeosporium melongenae* E & H).—The first planting was of the long purple variety and for some time was quite free of disease. When in full bearing the fruit on certain plants was attacked by anthracnose, which from that time on increased until at the time the bed was abandoned and the plants pulled, practically all of the fruit on all plants was affected. It seems probable that the fruit on naturally weak plants was attacked first, and then as the other plants were weakened through nematode attacks and other agencies, the disease spread to all. The fact that, owing to lack of a market, the fruit was not picked more than a few times doubtless assisted.

The disease was characterized by sunken, more or less circular, pits of varying size up to half an inch, often coalescing. Many fruits were so severely attacked that from a half to three-quarters of the surface was cankered. Fruit of all sizes was attacked, and when seriously infected dropped to the ground, leaving the pedicel still attached to the plant. The conidia occurred in salmon-pink masses (*sporodochia*) clustered in the bottoms of the pits.

It is not likely that spraying will avail against this disease. Resistant or non-susceptible varieties properly cultivated and kept free of nematodes or other weakening agencies will prevent serious loss.

WILT OR CROWN ROT (*Sclerotium rolfsii* Sacc.)—Several plants were killed by this fungus early in the season. The cases observed were all very characteristic. There was a rotting of the roots and of the bark at the crown, accompanied by production of white mycelium both on the roots and at the base of the stem. Later brown sclerotia appeared around the crown and on the surface of the soil adjoining. When occurring together with root-knot, death of the plant was especially rapid. *Scleria pterota* and *Alternanthera sessilis*, weeds growing adjacent to the eggplant, were found attacked in one instance.

LEAF SPOT, FRUIT ROT (*Phomopsis vexans* [Sacc. & Syd.]) Harter.[1]—This fungus caused a leaf spot, fruit rot and stem blight or canker of the New York spineless variety grown in the second planting. As a leaf-spot fungus it has been commonly known as *Phyllosticta hortorum* Speg. Neither the anthracnose nor other diseases were observed on this variety. Commercially the crop was a total failure as a result of the combined attacks of this fungus and insects.

[1] Identification verified by Mr. L. L. Harter, Pathologist, Bureau of Plant Industry, U. S. Department of Agriculture.

Bordeaux and lead arsenate applied at intervals of a week sufficed to check the disease to some extent and to stop the insect attacks, but were of no practical value. No salable fruit was obtained.

On the leaves this disease occurred as brown spots, varying considerably in size and shape. On seedlings in flats they were small, hardly over one-eighth inch in diameter, more or less circular, and attacked the older, lower leaves. At this stage it appeared to be merely a disease of old over-mature leaves, or of plants held too long in the flats and so weakened. However, the disease appeared on plants in the field, causing large irregular, dull-brown spots on the leaves and brown, sometimes sunken, lesions on petioles and young stems. Branches or twigs were often girdled, and in some plants this was so common that nothing remained alive beyond a short length of the main stem. The fungus produced nearly circular, raised areas on the fruit, hardly different in color at first from the normal skin of the fruit, but soon coalescing to form black areas covering large portions of the surface area. The calyx lobes and pedicels were also often attacked, resulting in irregular, sunken brown cankers. In all diseased areas the fruiting bodies appeared as minute black points, but were especially prominent in the fruit and stem cankers. There was at first a soft rot with same leaking, and the fruit very soon fell to the ground, leaving the infected pedicel and calyx on the plant. Within a short time it became a black, wrinkled mummy.

FRUIT ROT (*Diplodia* sp.)—Fruit of the long purple variety was rotted by a species of *Diplodia* not at present distinguishable from *Diplodia natalensis*, the cause of stem-end rot of Citrus. Innoculations have not yet been carried out. The fungus apparently attacked through the stem end, causing the fruit to drop to the ground, where it was soon mummified by a dry rot. The pedicel and calyx remaining on the plant had much the same appearance as when attacked by *Phomopsis.* There were first brown lesions followed by death and complete withering and drying. The rot of the fruit progressed very rapidly to the blossom end, appearing, externally medium brown in color, internally light brown, with no juice exudate. Only young fruit were observed attacked. The pycnidia produced in a damp chamber resembled those of *D. natalensis* on Citrus.

ROOT KNOT (*Heterodera radicicola* [Greef.] Mül.)—Some few plants were attacked by root knot. Except where *Sclerotium Rolfsii* was also present no perceptible damage resulted, although the plants were undoubtedly weakened by the presence of these parasites.

A *Nectria* sp. was found at the base of a plant that had been killed by *Sclerotium,* so that it can be considered only as a sapro-

phyte. There were no other disease symptoms than those due to the *Sclerotium*.

Damping-off of seedlings in flats was due to *Fusarium* sp. Care in watering and in the use of sterile or new soil should obviate this trouble.

Henricksen (5) reports bacterial wilt (*Bacillus solanacearum* Sm.) as very common. Such cases of wilt as have been found in the present investigation were, however, in all cases easily attributable to *Sclerotium* and root knot.

Gandul, Pigeon Pea (*Cajanus indicus*).

The gandul or pigeon pea is subject to a number of fungus diseases which tend to shorten the life of the plants.

One of the commonest is *Cercospora Cajani* P. Henn., causing a leaf spot. The spots are numerous, subcircular to irregular, medium brown in color, margin indistinct, appearance much the same on both surfaces. Affected leaves are shed sooner than normal ones.

Rust (*Uromyces Dolicholi* Arthur).—The rust, while quite common, causes very little damage. It is characterized by small, deep-brown, powdery pustules on the lower leaf surfaces.

A very serious stem canker, apparently due to a fungus not yet determined, has been observed in several localities, but studies have not been carried out. Numerous other fungi aid in the death and rotting of stems of mature plants, notably *Megalonectria pseudotrichia*[1] and others of the same group.

Lettuce (*Lactuca sativa*).

Leaf Spot (**Cercospora lactucae n. sp.**)—But one disease was found on lettuce and that of minor importance. This was a leaf spot due to an apparently new species of *Cercospora*, which is described below. The fungus attacked principally the older and lower leaves and caused slight injury as long as the leaves were gathered regularly. At the time of production of the flowering stalk, however, it rapidly spread to all leaves and, the numerous spots becoming confluent, practically the entire leaf surface of the plant was destroyed.

Cercospora lactucae sp. nov.—Spots amphigenous, drab (Ridgeway, Plate XLVI), subcircular to angular, slightly sunken, with definite margin (not raised), one to eight millimeters in diameter, often confluent especially along margin and tip; conidiophores amphigenous, fascicled, few (four to ten to each fascicle), simple, four

[1] Determined by Dr. F. J. Seaver, of the New York Botanical Garden.

to eight septate, 15–50 by 5–7 mu., medium brown, tips paler; conidia clavate to long clavate, often curved, hyaline to smoky, six to twelve septate, tips often non-septate, 3.5–5 by 50–100 mu.

On leaves of *Lactuca sativa* L. in Porto Rico: Río Piedras, 6244 (type), 5071, 5613.

MARIMBO, GOURD (*Lagenaria leucantha*).

A leaf spot (*Cercospora cucurbitae* E & E) occurred on this host. The spots were numerous, nearly circular, up to eight millimeters in diameter, brown at first, becoming dull white or tan at the center, with a slightly raised, definite margin, and red brown in color, causing the death of the older leaves.

MUSKMELON (*Cucumis melo*).

The growing of melons has been as little successful as that of cucumbers. Several diseases are in large measure responsible for this condition, although unsuitable varieties and poor cultural practices must be blamed in part.

On the early (December) plantings the downy mildew (*Pseudoperonospora cubensis*) was especially virulent and accounted for the death of the plants. Spraying with Bordeaux mixture (3–3–50) was without apparent effect. The symptoms were the same as on cucumbers.

ANTHRACNOSE (*Colletotrichum lagenarium* [Pass.] Ell. & Hals).—Plantings made later in the season were subject to other leaf diseases, and while not so quickly destructive as the mildew they were quite effective in cutting down the yield to practically nothing. The most important of these was the anthracnose which appeared as irregular brown spots or patches on the leaves. These soon coalesced causing the death of the entire leaf. Often the centers of the diseased areas dropped out leaving large ragged holes. Lesions on petioles and stems were also produced. This disease has been reported as serious on the fruit and would doubtless have proved so in this case if there had been fruit present in any amount.

Occurring sometimes in the anthracnose spots and at other times alone, another fungus was found, *Phyllosticta citrullina*. Spots caused by this fungus were light brown, nearly circular, and with the minute black fruiting bodies (pycnidia) clustered at the center. Of minor importance.

CHLOROSIS.—One case of chlorosis was found in which an entire plant had taken on a yellow color, portions of the stem only re-

maining green. The leaves were small, wrinkled and thicker than normal. Inoculations with material from this plant on other non-chlorotic plants were without result because of the death of the plants from other diseases.

MUSTARD (*Brassica* spp.).

The common mustard grown chiefly for the leaves, which are used as greens, is subject to several leaf diseases. The white rust (*Albugo candida* [P.] Rouss.) is common, producing numerous white pustules on the lower leaf surfaces.

A leaf spot (*Cercospora bloxami* Berk. & Br.) causes the death of the leaves in many cases. The spots are at first nearly circular (hardly spherical as given in one description), white or dull yellow in color and up to half a centimeter in diameter. They very soon run together, however, destroying the leaf.

OKRA (*Hibiscus esculentus*).

Okra was commonly subject to a leaf disease due to *Cercospora hibisci* T. & Earle). This fungus did not occur in definite spots, but rather in indefinite sooty patches often confluent on the lower surfaces of the leaves. The leaves were sapped of their vitality, turned yellow and dropped. The result was a tall stem, bare of leaves except at the tip and bearing very little fruit. No experiments for control have been tried.

ONION (*Allium cepa*).

Onions are raised to a considerable extent in the western part of the Island. Opportunity, however, has not been had to examine any of the plantings. Reference is made by Henricksen (5) to smut (*Urocystis cepulae* Frost) and to downy mildew (*Peronospora Schleideniana* De Bary) but without definitely reporting them as present in Porto Rico.

PEA (*Pisum sativum*).

Wherever observed the garden pea has been subject to powdery mildew (*Erysiphe polygoni* DC?). This fungus formed a thin gray or white coating over leaves and pods, and while it did not actually kill the parts attacked, it checked the growth and so lessened the yield. In common with all other powdery mildews collected on various plants, wild and cultivated, the conidial stage only was found. This disease could be readily controlled if necessary by Bordeaux, or other fungicide.

In one instance a leaf spot due apparently to *Cercospora* sp. has been collected. The spots were small (two to three millimeters in diameter) amphigenous, circular to angular, without a definite margin, dull brown to gray, often coalescing and causing a yellowing and subsequent death of the leaf. Fruiting on both surfaces. Conidia hyaline, long clavate, strongly septate. If, as appears certain now, this species is undescribed, a complete description and name will be published later, together with more complete notes on the nature and amount of injury caused by it.

Peanut (*Arachis hypogea*).

The peanut was subject to two leaf diseases, both quite effective at times in reducing the yield. Other diseases due to *Sclerotium Rolfsii*, or to other root-rot or wilt inducing fungi, have not been observed, but doubtless occur, or will with any extension of planting.

Leaf Spot (*Cercospora personata*).—The leaf spots caused by this fungus were nearly circular, brown to black with an indefinite margin, and generally numerous enough to practically cover the leaf surface. The lower leaves were attacked first, but the others soon succumbed in turn. It was difficult to estimate the damage, some growers declaring that the disease appeared after the crop was practically mature and that hence no damage was done.

Rust (*Uromyces arachidis*).—This fungus attacked all varieties, causing innumerable small golden brown to dark-brown pustules on both sides of the leaves, in many cases practically covering them and undoubtedly doing some harm since the effective leaf surface was reduced. In fact, experiments in the British West Indies have shown that decreased yields do result from attacks of this disease. Spraying with Bordeaux at intervals of a week was reported to have been without effect in checking or controlling either of these diseases.

Pepper (*Capsicum annuum*).

Fruit Rot.—The peppers of the first planting (Neapolitan) remained comparatively free of this trouble, but those of the second were seriously attacked. These varieties were Sweet Mountain, Large-bell, Chinese Giant and Ruby King, all of which were attacked to about the same degree, in so far as preliminary observations of one year show. At the time the first picking was made a large percentage of the fruit was found to have on one side or at the blossom end rotted areas. These were in general medium to light brown in color or at times nearly white, with definite margins and often sunken.

The affected tissues were softer than the normal, but still quite firm, and there was no juice exudate. In many cases the spots had all the appearance of sunburn or other non-parasitic causes. Fruit so affected soon dropped, unaffected portions turning a deep red and the whole fruit ultimately mummifying. It was noted that the fruit of certain plants remained comparatively free of the disease, while all of the fruit on other plants was affected, the weaker plants apparently. Certain fungi were commonly found associated with the spots, in particular *Cladosporium herbarum*, *Fusarium* sp., *Pestalozzia guepinia*, and *Macrosporium* sp. *Macrosporium* sp. is ordinarily considered the cause of a serious rot of peppers, but in the present instance it was found in so few cases that it is grouped temporarily at least with the other forms. Further work is necessary to ascertain the exact relations of these fungi to the disease. This may result in the division of the disease into both parasitic and non-parasitic types as is suggested by observations to date.

ANTHRACNOSE.—In the early stages it was not always possible to distinguish this disease from the above. In general, however, it was marked by more nearly circular areas, often several on one fruit, and more definitely sunken. The spots showed first as water-soaked areas turning brown. The fruit ripened prematurely, became shriveled, but quite often remained hanging to the plant. Two fungi were found in connection with this disease, *Gloeosporium piperatum* E. & E. and *Colletotrichum nigrum* Ells. & Hals., which after further work may prove to be the same, the presence or absence of setae in the fruiting bodies being the only point of difference, which is a doubtful character at best. At the first report of trouble with fruit rot spraying with 3–3–50 Bordeaux was commenced and continued at intervals of a week until eight applications had been made. Counts were made of the diseased and sound fruit at each picking. At no time was it possible to find any constant difference in amount of disease between sprayed and unsprayed areas. The percentage of spotting at first very heavy, gradually declined through the season, due apparently to cultural and climatic reasons; certainly independent of the spraying.

WILT (*Sclerotium Rolfsii* Sacc.).—This common disease of sugar cane (red rot of the leaf-sheath) attacked several of the vegetables and was especially serious on the peppers. Plants attacked by this fungus exhibited first a slight drooping of the leaves exactly as occurs when there is a shortage of water. The wilting increased each day with partial recovery at night until at the end of four or

five days the plant was practically dead. Examination of wilting plants showed healthy tops, but further search revealed brown sunken lesions at the crown, which grew rapidly until the stem was girdled and death resulted. A scanty white mycelium was generally present in these areas spreading down along the roots for some distance, rotting and killing them, as well as out over the surface of the ground, attacking weeds or other plants with which it came in contact. At the base of the diseased plant, there was in most cases an abundant production of the so-called sclerotia or fruiting bodies, yellow to dark brown, nearly spherical bodies, of about the size of mustard seed. Sclerotia from peppers produced typical cases of red rot of the leaf-sheath when transferred to cane.

All four varieties of the second planting were attacked and to about the same degree. The loss was greatest in the lower ends of the rows where there was possibly more moisture, although plants in all parts of the field were lost. About three per cent of the plants were killed.

Leaf Spot (*Cercospora capsici* H. & W.)—This leaf spot was most abundant and was collected or observed in numerous localities. The determination is provisional. The spots were circular, varying in size from a sixteenth to half an inch in diameter and were often very numerous. Their appearance was the same on both sides of the leaf, not raised, but rather slightly sunken with definite margins. The color was a dark dull brown with dirty white center and a surrounding faint halo of yellow. Centers of old spots often broke out irregularly. All varieties were very subject to attack. Older and lower leaves were first infected, turned yellow, and dropped. At times no further damage occurred, but quite often nearly complete defoliation resulted.

This disease was readily controlled by Bordeaux mixture. No spotting occurred on sprayed rows.

Root Knot (*Heterodera radicicola* [Greef] Mül.)—Peppers are very much subject to root-knot and serious damage often results. The trouble is prevalent in many parts of the Island. See under tomato.

Potato (*Solanum tuberosum*).

Potatoes do not thrive, at least in the lowlands, and it is extremely doubtful whether any results can be hoped for in any part of the Island. A root rot has been reported (1), and the opinion is there given that the disease will prevent the growing of potatoes in Porto Rico. The fungus concerned was not determined.

ROSELLE (*Hibiscus sabdariffa*).

Barrett reported (3) a root rot of this plant, possibly due to bacteria. Not observed in the present investigations.

SESAME (*Sesamum orientale*).

This plant, locally known as "ajonjolí," is commonly subject to a leaf spot attacking particularly the lower leaves, although instances have been observed of mature plants which had been practically defoliated. The spots, due to *Cercospora Sesami* Zimm, are very numerous, small (not over two millimeters in diameter) subcircular to angular, dull white to gray, with a definite, slightly raised deep brown margin. Sporulating on the upper surface.

SQUASH (*Cucurbita moschata*).

In so far as observed this crop was free of disease, even when in proximity to other cucurbitaceous plantings, such as cucumbers or melons. Henricksen (5) reports downy mildew as an enemy of the squash.

SWEET POTATO (*Ipomoea batatas*).

The sweet potato is one of the most common of the native crops, and while no large plantings are made the total of the innumerable small patches is considerable. As is usual with a crop which is not planted in large or continuous areas, serious diseases seem to be lacking. There have been reports received of losses, but in so far as it has been possible to discover from specimens submitted, insects have been to blame. However, it is known that some at least of the dry rots reported for other countries do exist here, and an effort will be made to find them.

WHITE RUST (*Albugo ipomoeae-panduranae* [S.] Swing.)—Only three fungi have been encountered on this host, all leaf parasites. The most common of these was the white rust, which caused indefinite spots varying from the size of a pinhead to half an inch or more in diameter. At times whole leaves were deformed and swellings produced on stems and petioles. The spots were yellow to brown above, and below showed the white pustules formed by myriads of spores. All of the various types or varieties of sweet potato, both cultivated and wild, have been found subject to attack.

LEAF SPOT (*Phyllosticta batatas* E. & M.)—In one instance leaf spots due to this fungus were found. The spots were circular to angular, up to one-quarter inch in diameter and light gray in color

with a definite brown margin. The minute black pycnidia were clustered at the center.

RUST (*Coleosporium Ipomoeae* [Schw.] Burr).—The rust was of common occurrence but cannot be considered of any economic importance. Small yellow pustules broke out on the under side of the leaf.

Two species of sooty mold (*Meliola clavulata* Wint. and *Meliola Ipomoeae* Earle) occur on this host, but without causing apparent injury.

TOMATO (*Lycopersicon esculentum*).

The tomatos in the test plots as well as those observed in gardens about the Island have suffered most severely from a number of diseases, which can be held responsible in large measure for poor yields obtained in some cases and the failures in others. There is again to be noted the occurrence of different diseases at different seasons of the year.

LEAF MOLD (*Cladosporium fulvum* Cke.)—This fungus also occurs commonly on the wild berengena (*Solanum torvum*), a very common weed in all parts of the Island. All varieties of tomatos (Trophy, Livingstone globe, and Ponderosa) in the first planting (December-February), as well as those in other gardens growing at this time of the year were attacked. The disease commenced in the shelter of the windbreak and spread very rapidly over the entire garden. The lower leaves were attacked first, but with little delay the balance of the plant was infected, only the very tips remaining free. Diseased leaves soon withered and dropped with the result that the plant consisted of but a few long spindling stalks devoid of mature leaves or fruit. Removal of diseased leaves was without effect in checking the spread of the fungus.

Spraying with Bordeaux was commenced before the *Cladosporium* appeared, and although various strengths, combinations with lead arsenate, and different kinds such as paste, powder, and home-made solutions were tried, no differences were at any time observed between sprayed and unsprayed rows. The number of sprayings varied from three to eight on the different plots and were at intervals of a week except in one instance, twice a week.

The fungus was virulently parasitic, occurring on the lower surface of the leaves in irregular velvety patches, which were white at first, then brown, and finally nearly black. The various patches soon coalesced by which time the leaf was yellow and curling.

This disease was not found on any of the varieties grown in the

second planting (April-June). *Solanum torvum* was also present in abundance at this time, but was free of disease.

Leaf Spot (*Septoria lycopersici*) Speg.—This fungus caused very definite spots in contrast to the effuse irregular areas of the *Cladosporium*. The spots were more or less circular, appeared the same on both sides of the leaf and were quite small, hardly ever more than one-eighth inch in diameter with a definite dark brown margin. They were brown to nearly black with the minute black fruiting bodies (pycnidia) at the center. When the spots became numerous, as was the case with all the varieties of the first planting, the leaves turned yellow, curled, and dropped. Lower leaves succumbed first. In combination with leaf-mold this disease was the cause of much damage through defoliation and consequent reduction of yield. Some few fruit only were found bearing the characteristic spots. It was especially a disease of young plants in flats or pots, tending to produce weak spindling plants, which if not entirely ruined by this cause remained weak or fell easy prey to other destructive agencies. As noted in the leaf-mold discussion, spraying and other measures were of no avail.

In the second planting *Septoria* appeared only after the plants were well advanced in contrast to its attack of the plants of the earlier crop in the seedling stage. It did not prove serious. Lower leaves were killed, and together with the *Phoma* spot some dying of the upper leaves occurred, but in no way to be considered serious. Spraying was again without effect.

Blossom-End Rot.—Considerable trouble was experienced with a blossom or point-end rot, which was apparently due to cultural conditions rather than to any parasitic organism. A *Fusarium* sp. quite commonly occurred in the rotted areas, but it is not likely that it was other than saproyhytic since it was generally present in advanced cases only and sometimes not at all. It formed pink and white masses of mycelium and conidia over rotted areas.

The rotted areas were medium brown in color, nearly circular, at first limited to a small area around the blossom end, but soon enlarging until one to two inches in diameter, at about which time the fruit dropped. The spots were only slightly sunken if at all and but little softer than normal tissues until secondary decay set in due to bacteria or saprophytic fungi. All varieties of the first planting were subject, the loss running around ten per cent. The trouble was not experienced in the second planting, possibly due to more satisfactory moisture or cultural conditions.

Soft Brown Rot.—In the second crop there was some loss from

a soft brown rot apparently due to an undetermined fungus of the *Phycomycetes* or alga-like fungi. This occurred more commonly on fruit hanging close to the ground or actually in contact with it. In the latter case there was a surface growth of white flocculent mycelium. The rot commenced as a discolored or water-soaked area, soon becoming dull brown and spreading irregularly over the balance of the fruit, accompanied by a heavy exudation of juice.

ANTHRACNOSE (*Colletotrichum phomoides* [Sacc.] Chester).—Some few cases of this disease on ripe fruits were collected. It caused sunken, circular areas on the side or end of the fruit, often of considerable size, in which appeared the pink (or in advanced cases black) conidial masses. Of slight importance.

Following cracks, insect and mechanical injuries or other wounds bacterial soft rot was common.

ROOT-KNOT, NEMATODES (*Heterodera radicicola* [Greef] Müll.)—The losses due to the attack of this minute worm have been heavy and much more in fact than is generally realized because of the fact that it works below ground. Attacks by this parasite will explain to some extent, it is thought, the weakness of not only the tomatos but of other crops permitting leaf and fruit parasites to make headway in spite of spraying or other preventative measures. In the Station plots tomatos suffered most severely, but eggplant and peppers were also attacked. At the end of the season examination showed a hundred per cent infestation of all varieties, certain ones, however, maintaining growth in spite of the nematodes and even giving a crop of fruit.

Where death occurred, the first symptoms were a slight wilting of the upper leaves, which increased until within a few days the entire plant was involved and death ensued. Upon pulling a wilted plant, the roots were found malformed or to consist of a series of enlargements or galls. Within these swellings the presence of the parasitic worms or nematodes in various stages was easily demonstrable with the microscope. Various fungi contributed to the death of attacked plants and speedily rotted away roots and crown, liberating a new brood of worms into the soil, so that in old cases nothing remained but the woody tap root and fragments of secondary roots and galls. The nematodes liberated in this manner remain in the soil for a number of years and are capable of reinfesting any new plants that may be set out.

Certain varieties in particular of the second planting, namely, Stone, Duke of York, Matchless, and Beauty were practically destroyed, the potting soil having been infested apparently. It was

noted that those supplied with manure survived, which suggests a means of control by supplying improved cultural conditions together with care in avoiding infested soil. Where possible infested soil should be sterilized by steam or by fire before using in flats or pots. This will insure healthy plants.

Black Spot (*Phoma destructiva* Plowr.)—The Livingston Globe variety and to a less extent other varieties in the second planting were attacked by this recently described disease (6). The spots, similar on both sides of the leaf, were brown with a definite dark brown margin, circular at first, then irregular, and finally confluent, causing the death of the leaf. Very few spots were found on the fruit, and these apparently following injuries from other causes, sucking insects, etc. The fungus agreed with the description given of *Phoma destructiva*.

Wilt (*Bacillus solanacearum* Erw. Sm.)—This serious disease has on several occasions been reported from Porto Rico (1) and doubtless does occur on tomato as well as on other related plants, but it has not been found in the present investigations. In the brown-stained vascular tissues of the lower portion of the stalks of plants killed by nematodes, bacteria were present, but were not capable of independently causing wilt of otherwise healthy plants. Nematodes were the causes of all cases of wilting which it has been possible to examine.

Minor Troubles.—Splits and cracks were very common. They can doubtless be attributed to extremes in the water supply, a drouth followed by excessive rains, excessive fertilization, and the like.

One case of rosette was observed. No cause was discerned nor was the juice of the plant infectious.

"Damping-off" of seedlings occurred as with eggplant and due apparently to the same cause.

Phytophora infestans Mont (De Bary) (Downy Mildew) has been reported from near Maricao by Prof. Whetzel and Dr. Olive, but has not been with certainty seen here. It is also reported by Henricksen (5).

Turnip (*Brassica campestris* and *B. Rapa*).

A leaf spot (*Cercospora Bloxami* Berk. & Br.) is reported (11) on this host. This is the same fungus as given under mustard. Not serious.

Black rot (*Bacterium campestris* Er. Sm.) is also reported (5) but has not been encountered by us.

WATERMELON (*Citrullus vulgaris*).

The leaf spot (*Cercospora citrullina*) mentioned in the last report (10) continues to be present and through the killing of the leaves is most effective in reducing yields. Also reported from Mayagüez (5).

BLOSSOM-END ROT.—This year a blossom-end rot of the fruit was observed. The blossom end of a fruit attacked by this disease dried up and turned brown, although the remainder of the fruit sometimes continued to enlarge for some time. Fruit of all sizes were attacked. Various fungi gained entrance and set up a soft rot with juice exudate. *Diplodia* sp. was found in several instances associated with this rot and also as the apparent cause of a stem-end rot in one case. No studies have been made of this fungus.

It was observed that this trouble was most prevalent during a drouth, but that later when the plants were growing vigorously under the stimulus of an abundant water supply, it practically disappeared. Irrigation or frequent cultivation will doubtless check the disease fairly well.

YAUTÍA (*Colocasia* sp., *Xanthosoma* sp.)

The yautías were quite subject to a disease known as "El mal" and probably due to a vascular parasite, although there was no opportunity to investigate it. Plants attacked by this disease failed to thrive, the leaves remained small, and were generally yellow. The yield was greatly reduced. The disease was favored by poor soil and dry weather. It can be avoided by care in planting only healthy "heads" or offsets in uninfected soil.

Phyllosticta colocasicola Höh. has been reported (7) on Colocasia sp. Other fungi (*Periconia* sp. and *Gloeosporium* sp.) are mentioned as occurring in spots on *yautía*. Of minor importance.

CONCLUSION.

Studies to date have been merely preliminary, a survey of the field as it were. However, certain points have become clear as regards the presence of diseases. It can be taken for granted that they will appear, and consequently all steps possible should be taken to control or minimize their attack. Most of the problems must be met by producing or introducing resistant varieties, a proposition for the plant breeder and one that requires time. Much can be done, however, and fair crops of most vegetables realized by following such corrective measures as are now known, such as proper preparation

of seed beds, thorough cultivation, irrigation and drainage, and the destruction of weeds.

After each crop all old plants and débris should be burned and a proper rotation maintained. Spraying with the various fungicides will be found of value for many of the diseases.

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A METHOD OF IDENTIFICATION AND DESCRIPTION OF SUGAR CANE VARIETIES, AND ITS APPLICATION TO TYPES GROWN IN PORTO RICO.

By H. B. Cowgill, Plant Breeder, Insular Experiment Station.

The number of varieties of sugar cane (*Saccharum officinarum*) is increasing rapidly.* and for this reason it is desirable to have a method of describing and identifying them. In some cases the points of difference are easily seen, but usually this is not so. This may be due to any of the following reasons: first, that there is a wide range of variation within the varieties, so that, as a consequence, the type is not represented in a single stalk, or in a single plant: second, that a large number of varieties tends to make the differences between some of them very slight: and third, that the differences are quantitative variations of characters common to all, and not the addition of definite new characters. The distinguishing marks are not always found on all the stalks. The type is in many cases difficult to determine, and although two varieties grown side by side may be seen to be distinctly different, it is not always easy to state wherein the differences lie.

Cane varieties vary widely in economic characters as well as in appearance. These characters are yield of cane, sugar content, milling quality, resistence to diseases, resistence to unfavorable conditions for growth, and so forth. Some varieties are much better suited to certain localities than others, and in Porto Rico it may be said that the four kinds of cane extensively cultivated are most commonly grown in more or less well-marked regions. This seems to be largely due to soil and climatic conditions, although it is difficult to state definitely, in every case, the exact factors which control their distribution.

THE PARTS OF THE SUGAR-CANE PLANT.

The sugar cane belongs to the grass family, or *Gramineae*, subfamily *Poacoideae*, tribe *Andropogoneae*, and genus *Saccharum*. The stems are unbranched and solid. The leaves are alternate and are

* The increase in the number of varieties is a result of breeding, conducted for the purpose of securing superior kinds. This is being done in practically all cane-producing countries. It was commenced in Java in 1887 and in the British West Indies in 1888, and was taken up on account of the advance made by the sugar beet industry in competition, and an apparent deterioration of the standard varieties of cane.

deciduous, with the apparent exception of certain varieties whose leaves adhere to the stalk after they have become dry. There is a bud at each node at the place of attachment of the leaf-sheath. The inflorescence is a many-flowered panicle. The spiklets are one-flowered, in pairs on an articulate rachis and are enveloped in long, silky hairs.

The cane, in common with many other grasses, is propagated by the development of rhizomes from underground buds, by the growth of buds of the stems when they come in contact with the moist soil, and by means of true seed. A stool of cane may be large or small, and may reproduce itself by rhizomes a greater or fewer number of years, depending on the tenacity of the variety and fertility of the soil.

The most important differences for purposes of identification are variations in the parts of the stalk. Differences in floral parts cannot well be used, because many varieties do not blossom, and because the period of flowering lasts only a few weeks. The stalk is the part of commercial importance and it is often desired to identify varieties by the stalk alone. However, the characters of the leaf are sometimes distinctive and may be used in identifying standing cane. More or less distinct differences are seen in the two parts of the leaf, the leaf-blade and the leaf-sheath.

The Stalk.—Stalks of different ages are usually found in a single stool, due to the fact that the buds from which they develop do not all start at the same time.* As stalks change in appearance towards maturity, neither very young stalks, nor those completely mature are most typical of a variety. The appearance of the stalk is also affected by its state of vigor, due to soil or climatic conditions. For example, a prolonged drought causes the internodes to grow short, whereas favorable moisture conditions produce long internodes and larger and plumper buds. A stalk of cane is composed of nodes, internodes, and buds, and these parts show characteristics which aid in distinguishing one variety from another.

The Internode varies in average length, diameter, and shape, being often nearly round, but frequently more or less flattened, sometimes tumid, and sometimes constricted, or larger on one side or at one end than at the other. In many varieties the internodes are more or less distinctly furrowed on one side, the furrow varying in length, depth, and width.

* The cane has a tendency to mature most rapidly in the fall and winter. The blossoming period is in November and December, and after blooming it comes to maturity more quickly, unless the occurrence of heavy rains retards ripening; but new stalks may appear at different times during the growth of the cane, and therefore the state of maturity of any stalk depends largely on its age.

The node varies mainly in form and size. The leaf-scar varies more or less in shape and prominence, and it is sometimes beset with short, stiff hairs. It divides the node into two parts: the part above the leaf-scar consisting of a band or ring, which varies in width and in form, and has many rudimentary roots, there being differences in the number, arrangement, and general appearance of these roots. The portion of the node below the leaf-scar is a more or less depressed ring extending around the stalk.

The Bud.—This usually shows greater varietal differences than the other parts of the cane. Buds vary in length, width, prominence, and shape. The outside scales show differences in shape, size, and texture; their outer edges form a flattened margin which varies in width and in form. Buds are more or less acute-pointed and sometimes bearded, or hairy.

The general characters of the stalk are its color, length, diameter, shape, and amount of glaucousness, or "bloom."

The Foliage, as a whole, varies in color and in relative abundance. The leaf-blade varies in length, width, shape, position, and color. The leaf-sheath shows differences mainly in shape, color, vestiture and tenacity to the stalk. At the place of union of sheath and leaf there are often characteristic differences. The edges of the sheath, just below the point of union of sheath and leaf, have appendages or "auricles," which vary in size and shape. The surface and edges of leaf and leaf-sheath also vary in amount and character of their vestiture.

TERMS USED IN DESCRIBING CANE VARIETIES.

It is necessary to take into consideration variations which exist within the varieties in making descriptions, as it is not always possible to find distinguishing, and at the same time plainly evident marks, so that usually the type must be gotten from several canes of the variety. Average canes should be described, the extreme variant forms being noted but given minor consideration. The most marked characteristics and their range of variability can be remembered for purposes of identification.

Special terms are used in this paper to describe various parts of the cane, as follows. The habit of the plant is described as erect, inclining, reclining, recumbent, or spreading. The term spreading indicates a tendency of the clump to recline in all directions from its center. The term staggered, as applied to the internodes, means alternating in their main axes, from forward to backward and vice versa. The term tumid means enlarged or swollen. "Shoulder"

is applied to a sudden increase in size, or an offset. The furrow is a channel sometimes extending up from the point of attachment of the bud, for all, or a part, of the length of the internode. Barbate signifies bearing hairs, or bristles, in a tuft, like a beard. Barbellate means beset with short, stiff hairs. The term margin is applied to the flattened edge of the bud, formed by the edges of the outside scales. Lobes are expanded areas of the lower part of the margin. Buds are described as prominent when they project from the stalk, depressed when the point is turned down upon the stalk, and appressed when flattened against it. The throat of the leaf-sheath is the region adjacent to the place where it joins the blade. The ligula is a membranaceous appendage of the leaf-sheath, extending up from the point of union of the sheath and blade. The auricles are lateral appendages of the leaf-sheath, just below the point of union with the leaf. Setae are hairs, or bristles, usually rigid and sharp pointed, but sometimes soft, which are often, but not always, found on the back of the leaf-sheath. The term vestiture applies to the setae or hairs occurring on the leaf-sheath or at its throat.

DESCRIPTION OF VARIETIES.

Following are descriptions of some of the cane varieties which have been under trial at this Station. The purpose is to show the application of a method used in identifying and describing varieties, as well as to give descriptions of some of the most important kinds in Porto Rico. The names by which they are known here may be different, in some cases, from their original names, as many of them came to us indirectly. The descriptions apply to the canes known by these names on this Island.

Otaheite.—Habit erect to reclining. Length medium. Diameter medium to large. Shape of stalk curved. Color greenish yellow, a glaucous ring on the lower half of the node. Internodes varying much in shape; typically rather tumid, but sometimes with sides straight, and when tumid most so on the side opposite to the one which bears the bud; somewhat flattened, usually more or less staggered; furrows medium to shallow. Nodes medium size, longest on the bud side; leaf-scar set more or less oblique and projecting somewhat prominently from beneath the bud; the portion above the leaf-scar about the same diameter as the internode above, except when the latter is tumid; the depressed ring, forming the portion below shallow; rudimentary roots in two or three rows. Buds typically sub-eliptical to ovate in outline but varying in size and in rela-

tive length and width; apex semi-elliptical to acute; margin narrow and conforming to the shape of the bud; no prominent lobes; sometimes hairy on the sides and bearded near the apex. Foliage medium abundant, light green in color. Leaf of medium width and length, tapering into a long and fine point. Leaf-sheath rather flattened at the throat; auricles medium to large, often long and acute-pointed on one or both sides of the stalk; ligula medium length, with the upper edge depressed in the center. Vestiture of leaf-sheath many setae which are stiff and not closely appressed. Vestiture of throat of sheath a small amount of medium fine hairs on or adjacent to the auricles. Most important distinguishing characters shape of the buds and of the internodes.

Rayada.*—Habit erect to recumbent. Length medium. Diameter variable but averaging about medium. Shape of stalk more or less curved. Color longitudinally striped with reddish-purple and light green, the stripes varying in width with different stalks and different internodes; more or less glaucous. Internodes medium to short, slightly flattened, typically plump, and more or less tumid on the side opposite the one on which the bud occurs, sometimes straight-sided, often staggered; furrow medium to shallow but usually broad. Nodes medium size; the portion above the leaf-scar often a little smaller in circumference than the internode, and usually a slightly projecting ring at the dividing line of the node and the internode above; the depressed ring forming the portion below typically deep, especially below the bud; the leaf-scar projecting from beneath the bud; rudimentary roots in about three rows. Buds varying in size and in relative length and width, typically broadly ovate-acuminate to broadly ovate in outline, sometimes obtuse-angular; usually plump; point rounded to medium acute; margin medium to wide, typically with medium to large lobes on the sides, often bearded at the point. Foliage abundant, the dry leaves also retained far down on the stalk, medium green in color. Leaf medium width, medium length, tapering into a long point. Leaf-sheath flattened laterally; auricles medium to small, sometimes pointed on one side of the stalk; ligula medium length, with the upper edge rounded in outline. Vestiture of leaf-sheath a few short setae in a line on the back. Vestiture of throat of sheath medium coarse hairs on, or adjacent to, the auricles and on the edges of the base of the leaf, also sometimes pubescent on the surface of the base of the leaf. Most important distinguishing characters color and the shape of the buds.

* This is the striped cane which is widely cultivated on this Island. It is apparently closely related to the Crystallina variety.

Crystallina.—Habit erect to recumbent. Diameter medium. Shape of stalk usually curved. Color varying from shades of greenish-red to straw color, sometimes tinted with violet or purple; very glaucous. Internodes varying in length, but averaging about medium; varying also in shape, often tumid on the side opposite the one on which the bud occurs, typically plump, and flattened laterally; furrow medium depth. Nodes medium size, typically larger in the upper part; the lower portion a distinctly depressed ring, which is deepest below the bud; the leaf-scar projecting prominently from beneath the bud, but adhering closely to the stalk on the opposite side; rudimentary roots in three or four rows. Buds varying in length and width, usually plump; typically broadly ovate-acuminate to triangular, with a margin medium to wide; sometimes broadly ovate or semi-elliptical; lobes typically distinct; may or may not start to expand on the standing cane. Foliage abundant, some of the dry leaves also adhere to the stalk, medium green in color. Leaf medium width, medium length, tapering into a long, acute point. Leaf sheath somewhat flattened laterally at the throat; auricles medium size; ligula medium length, with the upper edge rounded in outline, or occasionally slightly depressed in the center. Vestiture of leaf sheath a few setae in a line on the back. Vestiture of throat of sheath medium coarse hairs on auricles, adjacent edges and face of the leaf, and sometimes fine hairs on the surface of the base of the leaf. Most important distinguishing characters color and the form of the internodes and buds.

Cavengerie.—Habit erect to reclining. Length medium. Diameter medium. Shape of stalk more or less curved. Color dark wine to greenish-red, with faint greenish to bronze longitudinal stripes; the lower part of the node more or less glaucous. Internodes nearly round in cross-section, medium to long, typically almost straight-sided, but sometimes inclined to be tumid in the lower half; often more or less staggered; furrow very shallow. Nodes small; the leaf-scar often oblique, usually a slightly prominent ring at the upper limit of the node; the depressed ring forming the portion of the node below narrow and shallow; two, to occasionally three, rows of rudimentary roots. Buds usually dark in color, typically plump and very short, with the margin scarcely perceptible, and the point round and obtuse, set in a cavity of the stalk; but sometimes longer and the point more acute. Foliage abundant, medium green in color. Leaf medium width, medium to short, semi-erect, tapering to a fine point rather abruptly. Leaf-sheath slightly flattened at the throat; color reddish green, striped with light, longitudinal stripes; auricles small; ligula medium to narrow, turned in toward the stalk, and

with the upper edge depressed in the center. Vestiture of leaf-sheath many sharp, stiff setae. Vestiture of throat of sheath straight, rather short hairs on the auricles, adjacent edges of the leaf and leaf-sheath, and sometimes on the face of the base of the leaf. Most important distinguishing characters color, striped leaf-sheath, and form of the buds.

Yellow Caledonia.—Habit erect. Length long. Diameter above medium. Shape of stalk straight. Color greenish-yellow, tinged with red on the upper internodes and where exposed to the sun; with fine, dark-colored cracks in the epidermis; more or less glaucous on the lower part of the node. Internodes long and quite uniform; typically straight-sided, but sometimes slightly constricted and sometimes slightly sub-conical; no furrow. Nodes rather large; the portion above the leaf-scar long and about the same diameter as the internodes; about four rows of rudimentary roots; leaf-scar projecting prominently from beneath the bud. Buds usually small but uniform, about as broad as long, typically ovate to sub-elliptical in outline, plump and with a margin narrow but uniform as to width, and following the shape of the bud; scales of fine texture; bearded at the tip and sometimes pubescent on the sides. Foliage abundant, green leaves inclined to adhere to the stalk rather far down, but the dry leaves are shed; medium dark in color. Leaf broad, long, tapering medium abruptly into a point. Leaf-sheath large in circumference at the throat, color light green with sometimes a pinkish tinge; auricles small; ligula medium length, with the upper edge depressed in the center. Vestiture of leaf-sheath a few setae in a line on the back. Vestiture of throat of sheath short hairs on the auricles, adjacent edges and face of the base of the leaf, and sometimes back of the ligula; also sometimes finely pubescent on the face of the base of the leaf. Most important distinguishing characters color, cracks in the epidermis, and form of the internodes.

B-347.—Habit erect to reclining. Length medium to long. Diameter medium to large. Shape of the stalk usually straight. Color yellowish-green, with a tinge of red on the upper internodes; more or less glaucous; marked with irregular, light-colored spots, apparently caused by a loss of the cuticle. Internodes slightly flattened, medium length, usually staggered; sides sometimes straight but usually more or less tumid, mainly on the side opposite the one on which the bud grows. Nodes medium to large; the leaf-scar projecting out a little on all sides; above the leaf-scar often a little smaller than the portion of the internode just above it; rudimentary roots two to five rows. Buds typically long in comparison to width,

ovate to oval in outline, with the point extended flat against the cane; margin narrow, the point of the margin typically long and semi-elliptical in shape. Foliage medium in amount, medium green in color. Leaf of medium width, medium to short, sub-erect, edges having a tendency to curl. Leaf-sheath flattened laterally at the throat, glaucous; auricles medium size; ligula medium to short, with the upper edge usually depressed in the center. Vestiture of leaf-sheath many long and rather soft setae. Vestiture of throat of sheath medium abundant, long, rather soft hairs on the auricles, and adjacent edges and face of the leaf, and sometimes behind the ligula; also sometimes pubescent on the face of the base of the leaf. Most important distinguishing characters the form of the buds, curling of the leaf, and light colored spots on the internodes.

B-3412.—Habit erect to inclining. Length long. Diameter medium to small. Shape of stalk straight to slightly curved. Color greenish-red but varying in redness with amount of sun-exposure; a glaucous ring on the node below the leaf-scar. Internodes medium to long, nearly round in cross-section, typically straight or slightly depressed on the side above the bud but tumid on the opposite side; furrow just perceptible. Nodes medium size, typically larger above the leaf-scar than below it, slightly longer on the side of the bud; about three rows of rudimentary roots. Buds typically having started to expand, projecting through the outer scales and standing out from the stalk; before starting typically semi-elliptical to broadly ovate in outline, plump, adhering closely to the stalk, having a margin of medium width, lobes inconspicuous. Foliage rather less than medium, medium to dark in color. Leaf narrow, medium length, tapering into a long point. Leaf-sheath nearly round at the throat, often reddish in color; auricles medium size; ligula medium to short, with the upper edge rounded in outline. Vestiture of leaf-sheath many medium stiff setae. Vestiture of throat of sheath medium coarse hairs on the auricles and sometimes extending onto the edges and surface of the base of the leaf. Most important distinguishing characters color and the shape of the buds and the internodes.

B-109.—Habit erect to inclining. Length medium to long. Diameter medium to large. Shape of stalk more or less curved. Color greenish-yellow, with a glaucous ring below the leaf-scar. Internodes medium length, nearly round in cross-section; typically nearly straight-sided, but sometimes slightly staggered, and then slightly tumid on the side opposite the one on which the bud occurs; furrow not perceptible, or very shallow. Nodes medium size; above the leaf-

scar about as large or larger than the internodes, usually a prominent ring at the upper limit of the node; two to three rows of rudimentary roots. Buds typically variable in size and shape and more or less triangular in shape, usually short for their width, sometimes having the appearance of being five-sided; margin typically narrow and uniform in width with the sides of the bud, edges either straight, curved or irregular; lobes small or none. Foliage abundant; retained well down on the stalk, including some of the dry leaves; medium to dark in color. Leaf medium to broad, medium length, tapering into an acute point of medium length. Leaf-sheath almost round at throat, glaucous; auricles small, sometimes long-pointed on one side of the stalk; ligula medium to short, with upper edge rounded in outline. Vestiture of leaf-sheath a few setae which are short and soft. Vestiture of throat of sheath medium coarse hairs on the auricles, edges and surface of base of the leaf, and sometimes a few extending to the area behind the ligula. Most important distinguishing characters color and the form of the internodes and buds.

B-208.—Habit inclining to reclining. Length medium to short. Diameter medium to large. Shape of the stalk usually curved. Color medium green, more or less glaucous. Internodes nearly round in cross-section, typically short and tumid, and with a prominent shoulder on the side opposite the one on which the bud occurs; furrow very shallow. Nodes small; the portion above the leaf-scar a little longer, and larger in circumference than that below; the depressed ring forming the portion below the leaf-scar medium depth but narrow, deepest below the bud. Two or three rows of rudimentary roots. Buds typically having started through the scales and projecting out from the stalk in a globoid to conical point; before starting short and swollen; when very young typically flat, very broad and ovate-cuspidate in outline, with the margin extending across the top or rather than on the sides; lobes typically well-marked. Foliage medium in amount, rather dark in color. Leaf medium to short, broad, growing semi-erect, tapering medium abruptly into a point. Leaf-sheath broad, almost round at the throat, light green to reddish-green in color; auricles medium to small; ligula medium length, with the upper edge slightly depressed in the center. Vestiture of leaf-sheath many long, medium stiff setae, not closely appressed. Vestiture of throat of sheath medium soft hairs on the auricles and edges of the base of the leaf, and more or less on the adjacent area of the face of the leaf. Most important distinguishing characters form of the internodes and buds.

B-6450.—Habit reclining. Length medium. Diameter medium.

Shape of stalk more or less curved. Color green when young, yellowish-green when mature; the surface is smooth and sometimes glossy on the young stalks but when old it often contains fine cracks; usually glaucous on the lower portion of the node. Internodés medium length; typically variable in shape, but tumid on the side opposite the bud and more or less staggered; furrow broad and shallow, deepest underneath the bud. Nodes medium length; the depressed ring forming the portion below the leaf-scar medium width and depth, deepest immediately below the bud; rudimentary roots far apart, white, in two to four rows. Buds medium size, typically ovate to triangular in outline, rather flat when young; margin usually narrow and conforming to the shape of the bud; sometimes pubescent at the base. Foliage abundant, medium green in color. Leaf of medium length and width, tapering into a medium long point. Leaf-sheath flattened laterally at the throat; auricles medium to large, often a little more pointed on one side of the stalk than the other; ligula medium to long, with the upper edge rounded to obtuse-pointed in the center. Vestiture of leaf-sheath rather fine setae. Vestiture of throat of sheath medium soft hairs on the auricles and edges of the base of the leaf, and sometimes a few in adjacent area behind the ligula. Most important distinguishing characters color and shape of the buds and the internodes.

B-7245.—Habit erect. Length medium. Diameter medium to large. Shape of stalk straight. Color green to yellowish-green, some of the upper internodes slightly reddened; the lower portion of the node glaucous. Internodes medium to long, nearly round in cross-section, almost straight-sided, but the shorter internodes are tumid and the longer ones typically slightly constricted in the lower half on the bud side, or all around, making the upper half the largest in circumference; furrow broad but usually shallow. Nodes medium to large, the portion above the leaf-scar short on the side opposite the bud; typically smaller in diameter above than below; the upper portion increasing in size from below upward, and forming a prominant ring at the upper extremity of the node; the leaf-scar and the depressed ring forming the portion below it oblique; two to three rows of rudimentary roots, which are conspicuous. Buds varying in size, generally adhering closely to the stalk, usually about as broad as long; typically ovate to broadly ovate in outline, with the point rounded and the margin medium to narrow; sometimes bearded at the apex. Foliage abundant, medium green in color. Leaf medium to wide but variable, medium length, tapering into a medium to long point. Leaf-sheath distinctly flattened laterally at the throat; auri-

cles medium to large, those on one side of the stalk sometimes acute-pointed, and on the young sheaths, overlapped by the others; ligula medium to short, with the upper edge sub-elliptical, to obtuse-pointed in the center. Vestiture of leaf-sheath very long, sharp and prominent setae. Vestiture of throat of sheath medium soft hairs on the auricles, edges of the leaf, and a few back of the ligula. Most important distinguishing characters the shape and size of the internodes and the buds.

B–1809.—Habit erect. Length long. Diameter large. Shape of stalk straight. Color medium green when young, but becoming yellowish-green with age; a glaucous ring on the node below the leaf-scar, which becomes dark with the aging of the stalk. Internodes medium to long, flattened; typically nearly straight-sided or largest in diameter just above the node, where there is a prominent ring, and on the side opposite the bud a shoulder; furrow broad and rather deep, but narrower and shallower toward the top of the internodes. Nodes rather large; typically smaller below the leaf-scar than above, and increasing in size above until the lower limit of the internode is reached; two or three rows of rudimentary roots; the depressed ring forming the portion below the leaf-scar shallow on the side opposite the bud but deeper immediately below it. Buds typically long and more or less triangular in shape with the point either broad or acute; but sometimes about as broad as long, more or less ovate and acute-pointed; adhering rather closely to the stalk; often increasing in length on the standing stalk, but not usually projecting much through the scales; margin medium to narrow, and conforming to the shape of the bud, or forming small lobes at the sides; usually bearded near the point. Foliage abundant, medium green in color, many dry leaves also retained. Leaf medium to broad, medium length, erect growing. Leaf-sheath somewhat flattened at the throat, glaucous; auricles medium to small; ligula medium length, with the upper edge usually depressed in the center. Vestiture of leaf-sheath medium stiff setae on the back. Vestiture of throat of sheath medium long hairs on the auricles and edges of the base of the leaf, and sometimes a few on the adjacent areas of the face of the base of the leaf; sometimes slightly pubescent on the face of the base of the leaf. Most important distinguishing characters the shape and size of internodes, buds, and leaves.

B–3859.—Habit inclining. Length medium. Diameter medium. Shape of stalk more or less curved. Color wine to greenish-wine; a glaucous ring on the lower half of the node. Internodes medium length, nearly round in cross-section, varying in shape with different

stalks, sometimes straight-sided, but typically tumid in the lower part, especially on the side opposite the bud, and sometimes constricted above; more or less staggered; furrow shallow. Nodes rather long, considerably longer on the side to which the bud is attached; leaf-scar usually oblique; the portion above typically larger in diameter than that below; two or three rows of rudimentary roots; the depressed ring forming the portion below the leaf-scar medium depth and narrow. Buds typically expanded and projecting out from the stalk, but before starting adhering closely to the stalk and typically ovate to oval in outline; margin narrow and conforming to the shape of the bud, bearded at the point. Foliage abundant, medium green in color. Leaf medium width, length medium to short, growing erect, tapering rather abruptly to a fine point. Leaf-sheath flattened at the throat, reddish in color; auricles medium size but sometimes acute-pointed on one side of the stalk; ligula medium width, with the upper edge rounded to obtuse-pointed in the center. Vestiture of leaf-sheath a few short and fine setae on the back, rather closely appressed. Vestiture of throat of sheath medium long and coarse hairs on the auricles, the adjacent edges of the leaf, and sometimes a few behind the ligula. Most important distinguishing characters shape and size of the internodes and the buds.

B-6292.—Habit erect. Length long. Diameter small. Shape of stalk straight. Color light green to reddish-green, a glaucous ring on the node below the leaf-scar. Internodes almost round in cross-section, usually tumid on the side opposite the bud and slightly depressed on the bud side; furrow, when present, broad and shallow. Nodes medium size, longest on the bud side; the depressed ring forming the portion below the leaf-scar shallow. Buds usually having commenced to expand and standing out from the stalk, the shoot being acute-pointed and extending through the scales; when not having started to develop shoots the buds are typically broadly semi-elliptical in outline, with a margin of medium width. Foliage medium to abundant, medium green in color. Leaf narrow and long, tapering into a long point. Leaf-sheath slightly flattened at the throat; auricles large and obtuse-angular, except occasionally on one side of the stalk they are semi-acute pointed; ligula medium to long, with the upper edge rounded in outline. Vestiture of throat of sheath medium coarse hairs on the auricles and adjacent edges and surface of the leaf. Most important distinguishing characters the form of the buds and the long, slender stalk.

B-1753.—Habit erect to inclining. Length long. Diameter small. Shape of stalk straight. Color straw color to yellow, a glaucous

ring on the node below the leaf-scar. Internodes nearly round in cross-section, straight-sided or slightly depressed on the side on which the bud occurs, usually largest in diameter at the place of union with the node below; furrow shallow or none. Nodes medium to large; the portion above the leaf-scar long, typically large in circumference and appearing swollen, or expanding from the bottom upward to the lower limit of the internode; leaf-scar close to the stalk on the side opposite the bud but projecting out from beneath the bud; rudimentary roots very close together and in about four or five rows; the depressed ring forming the portion below the leaf-scar shallow. Buds close to the stalk, or slightly prominent; young buds typically flat against the stalk, ovate to acute, and with a narrow margin, uniform with the sides of the buds. Foliage rather scant, the leaves being shed far up on the stalk; light green in color. Leaf narrow, short, growing erect, tapering into a long point, sometimes breaking off at the throat and falling from the sheath. Leaf-sheath nearly round at the throat; auricles medium to large, sometimes long-pointed on one side of the stalk; ligula medium length, with the upper edge rounded in outline. Vestiture of leaf-sheath many soft setae. Vestiture of throat of sheath fine hairs on the auricles and adjacent edges and face of the base of the leaf. Most important distinguishing characters the shape and size of the nodes and buds, and the manner of growth of the leaves.

B-4596.—Habit erect to reclining. Length medium. Diameter medium to large, variable. Shape of stalk usually straight. Color yellowish-green to reddish green, usually more red just above the node, sometimes having spots of reddish-brown; glaucous, especially the lower portion of the nodes; having fine cracks in the epidermis. Internodes medium to long, more or less flattened, often larger above than below the node; typically straight-sided, plump; sometimes slightly tumid, sometimes subconical; often a typical shoulder just above the node on the side opposite the one having the bud; furrow medium depth. Nodes rather short; the depressed ring forming the portion below the leaf-scar distinct; rudimentary roots about two rows. Buds typically large and coarse but varying with the coarseness of the stalk, broad, obtuse to more or less acute pointed; the margin typically wide, with straight edges and large lobes; sometimes broadly ovate-acuminate in outline; occasionally starting and standing out slightly from the stalk but not producing sprouts. Foliage medium in amount, dry leaves readily shed. Leaf medium to broad, medium length, tapering into a point of medium length. Leaf-sheath flattened laterally at throat; auricles medium to small; ligula

medium length, with the upper edge rounded or slightly depressed in the center. Vestiture of leaf-sheath medium stiff, fine and short setae. Vestiture of throat of sheath medium fine hairs on the auricles, and adjacent edges and face of the base of the leaf; sometimes finely pubescent on the adjacent surface of the leaf. Most important distinguishing characters color and the form of the buds and the internodes.

B-376.—Habit erect to recumbent. Length long. Diameter medium. Shape of stalk more or less curved. Color varying from shades of greenish-red to straw color, and sometimes showing violet or purple tints; very glaucous. Internodes varying in length but averaging about medium; also varying much in shape, sometimes straight-sided and sometimes more or less tumid, mainly tumid on the side opposite to the one bearing the bud, typically plump, and slightly flattened laterally; furrow medium depth. Nodes medium size; the depressed ring constituting the portion below the leaf-scar distinct, deepest immediately below the bud; the upper portion usually about the same size as the internode, and often larger than the portion below; the leaf-scar adhering closely to the stalk on the side opposite the bud, but often projecting out prominently from beneath the bud; rudimentary roots three or four rows. Buds varying in relative length and width, usually plump, typically almost as broad as long and broadly ovate-acuminate to triangular in outline, obtuse to medium acute pointed; margin medium width, typically with distinct lobes; may or may not start to expand on the standing stalk. Foliage abundant, medium green in color, some of the dry leaves also adhere to the stalk. Leaf medium width, medium length, tapering into a long point. Leaf-sheath slightly flattened laterally at the throat; auricles medium size; ligula medium width, with the upper edge rounded in outline or sometimes slightly depressed in the center. Vestiture of leaf-sheath a few setae in a line in the back. Vestiture of throat of sheath medium coarse hairs on the auricles, adjacent edges of the base of the leaf, and sometimes fine hairs on the surface of the base of the leaf. Most important distinguishing characters color and the form of the internodes, and the buds.

Seeley Seedling.—Habit erect to inclining. Length long. Diameter medium to small. Shape of stalk slightly curved. Color greenish-red, but varying in redness with the amount of sun-exposure; the depressed ring of the node below the leaf-scar glaucous. Internodes medium to long, almost round in cross-section; typically straight or slightly depressed from the bud upwards, but more or less tumid on the opposite side; furrow just perceptible. Nodes medium size, typically

smaller below the leaf-scar than above it, longer on the side of the bud; about three rows of rudimentary roots. Buds usually having started to expand, projecting through the outer scales and standing out from the stalk; before starting typically semi-elliptical to broadly ovate in outline and adhering closely to the stalk; fairly plump; margin medium in width; lobes inconspicuous. Foliage rather less than medium, medium to dark in color. Leaf narrow, medium length, tapering rather gradually into a point. Leaf-sheath nearly round at the throat, usually reddish in color; auricles medium size; ligula medium to short, with the upper edge rounded in outline. Vestiture of leaf-sheath medium stiff setae. Vestiture of throat of sheath medium coarse hairs on the auricles, and a few extending up onto the adjacent edges and surface of the leaf. Most important distinguishing characters color and the shape of the internodes and the buds.

B-3747.—Habit erect to inclining. Length long. Diameter medium. Shape of the stalk straight. Color yellowish-green to reddish-green; more or less glaucous, especially the depressed ring forming the lower portion of the node. Internodes flattened; typically slightly larger in the upper portion, and with a tendency to be tumid, especially the shorter internodes and on the side opposite to the bud; the side on which the bud occurs is almost straight immediately above the bud, but often a little tumid just below the node; sometimes staggered; furrow rather broad but shallow. Nodes medium size, the portion above the leaf-scar longer on the side on which the bud is attacked than on the opposite; rudimentary roots quite abundant and distinct, in two or three rows; the depressed ring forming the lower portion of the node narrow and shallow; the leaf-scar more or less oblique and projecting from beneath the bud, ciliated with more or less deciduous hairs. Buds large or small, depending on the size of the stalk; often short in comparison with their breadth, triangular to ovate in outline, occasionally long and appearing shrunken; typically obtuse or blunt pointed, and with a narrow margin and having edges conforming to the shape of the bud. Foliage medium in amount, medium green in color. Leaf medium to broad, long, tapering into a long, acute point. Leaf-sheath distinctly flattened laterally at the throat; auricles small; ligula narrow, upper edge either rounded, slightly pointed, or slight depressed in the center. Vestiture of leaf-sheath many rather long and soft setae. Vestiture of throat of sheath hairs on auricles, adjacent edges of leaf, and sometimes a few on the adjacent areas of the face of the leaf. Most important distinguishing characters form of the buds and the internodes, and the ciliated leaf-scar.

B-3750.—Habit erect to inclining. Length medium. Diameter medium. Shape of stalk straight to slightly curved. Color greenish-yellow, sometimes reddened on the upper internodes; glaucous on the lower portion of the node. Internodes medium to long, slightly flattened; typically almost straight-sided, but slightly tumid on the side opposite to the one which bears the bud and a little larger on the upper portion; slightly staggered; furrow shallow or none. Nodes medium to small, the portion above the leaf-scar medium to short and longest on the side on which the bud is attached; two or three rows of rudimentary roots; the leaf-scar and the portion below it usually somewhat oblique; the former projecting prominently from beneath the bud. Buds medium size; typically broadly triangular in outline, having a wide margin with nearly straight edges; young buds more or less broadly ovate; scales of fine texture. The characteristic buds of this variety are those occurring more or less frequently on the upper part of the stalk, the margins having slightly increased in length and width. Foliage medium abundant, medium green in color. Leaf medium width, long, growing semi-erect, tapering into a long point. Leaf-sheath flattened at the throat; auricles small, sometimes acute-pointed on one side of the stalk; ligula short, with the upper edge rounded or slightly depressed in the center. Vestiture of leaf-sheath many setae which are long, rather soft, and not closely appressed. Vestiture of throat of sheath medium coarse hairs on the edges of the base of the leaf and the auricles, and sometimes fine hairs on the surface of the base of the leaf. Most important distinguishing characters the form of the internodes and of the buds.

B-3390.—Habit erect. Length medium to long. Diameter medium. Shape of stalk usually straight. Color reddish-green to green; more or less glaucous. Internodes nearly round in cross-section; sides typically nearly straight, but the longer internodes larger above the node than below it, and sometimes slightly constricted; often curved in above the bud and correspondingly tumid on the opposite side; furrow shallow and inconspicuous. Nodes medium size; rather larger above the leaf-scar than below it and largest on the bud side; below it a depressed ring of medium dimensions; rudimentary roots large and prominent, in two to four rows. Buds rather small, usually adhering closely to the stalk; margin typically subovate to acute in outline of medium width and conforming to the shape of the bud. Foliage medium abundant, medium green in color. Leaf medium to narrow, sub-erect, tapering into a long point. Leaf-sheath somewhat flattened at the throat, slightly glaucous; auricles medium to large; ligula medium in width, with the upper edge

slightly depressed in the center. Vestiture of leaf-sheath none. Vestiture of throat of sheath medium soft hairs on and adjacent to the auricles; also sometimes slightly pubescent on the face of the base of the leaf. Most important distinguishing characters the form of the internodes and the buds.

B–7169.—Habit erect. Length medium. Diameter medium. Shape of the stalk usually straight. Color yellowish-green to reddish-green, having a somewhat glossy surface and sometimes with a few fine cracks in the epidermis; the lower portion of the node sometimes glaucous. Internodes medium length, nearly round in cross-section; typically almost straight-sided but a little tumid on the side opposite the bud; the lower portion often slightly the largest and becoming smaller until the node is reached; furrow none or very shallow. Nodes medium size; almost uniform in length around the stalk, but the portion above the leaf-scar sometimes longer, and that below a little shorter on the bud side, the leaf-scar then being set at an angle; three or four rows of rudimentary roots, which show as white points. Buds regular in shape; typically ovate to acute in outline and acute-pointed; usually flat against the stalk but occasionally slightly prominent; margin narrow, with the edges straight or conforming to the shape of the bud; lobes small; scales of fine texture. Foliage abundant, medium green in color. Leaf medium to narrow, medium length, sub-erect, tapering into a medium long point. Leaf-sheath flattened laterally at the throat; auricles medium to small; ligula medium length, with the upper edge rounded to sub-elliptical. Vestiture of leaf-sheath a band of setae on the back, rather long and medium stiff. Vestiture of throat of sheath medium fine hairs on the auricles, adjacent edges and face of the leaf, and sometimes a few behind the ligula. Most important distinguishing characters color and glossy appearance, and the form of the internodes and the buds.

B–3405.—Habit erect to inclining. Length medium to long. Diameter medium. Shape of stalk nearly straight. Color reddish-green, being reddest in the upper internodes and where exposed to the sun; often glaucous on lower portion of the node. Internodes medium length, slightly flattened, typically slightly tumid on the side opposite the one which bears the bud, and sometimes a little sub-conical; often slightly staggered; furrow shallow but usually broad. Nodes medium size; leaf-scar often oblique and usually projecting prominently from beneath the bud; the portion above the leaf-scar rather long; the depressed ring forming the portion below medium width and shallow, excepting immediately below the bud where it

is deeper: two or three rows of rudimentary roots. Buds typically having started to expand on the standing cane and projecting from the stalk: before starting semi-elliptical to broadly ovate in outline: margin narrow in the young buds but appearing wide in the older ones, typically semi-elliptical pointed: lobes inconspicuous: sometimes slightly barbate at the point and barbellate on the sides. Foliage medium to scant, medium green in color, dry leaves well shed. Leaf medium to narrow, long, tapering into a long and fine point. Leaf-sheath almost round at throat, slightly glaucous; auricles medium to large: ligula medium width, with the upper edge either rounded in outline or slightly depressed in the center. Vestiture of leaf-sheath many setae, which are rather long and medium stiff. Vestiture of throat of sheath long and medium course hairs on the auricles and adjacent edges of the leaf, and sometimes a few on the adjacent areas of the face of the leaf. Most important distinguishing characters the form of the buds and the internodes.

D–117.—Habit erect. Length long. Diameter medium. Shape of the stalk straight. Color light green to yellowish-green. Internodes medium to long, slightly flattened: typically straight on the side opposite to the one on which the bud occurs, but on the bud side largest at the base and extending up nearly straight from that point: sometimes slightly constricted above the enlargement at the base: furrow, when present, shallow but rather broad. Nodes large, typically largest on the bud side above the leaf-scar: often a slightly prominent ring at the line of union with the internode above; leaf-scar projecting prominently from beneath the bud; rudimentary roots many and close together, in three or four rows. Buds typically broadly-ovate to triangular in shape and medium acute-pointed; margin medium to narrow, and uniform in width with the sides of the bud: lobes inconspicuous or none: sometimes bearded at the point and barbellate on the sides. These buds sometimes start to expand on the standing stalk, but they do not become prominent: the sprout from the bud is plump and medium obtuse pointed. Foliage medium in amount, medium green in color, some of the dry leaves are retained. Leaf medium in width, medium length, tapering into a medium long point. Leaf-sheath slightly flattened laterally at the throat: auricles medium size but sometimes long-pointed on one side of the stalk: ligula short, with the upper edge either rounded or slightly depressed in the center. Vestiture of leaf-sheath a few medium soft setae. Vestiture of throat sheath long hairs on the auricles, adjacent edges of the leaf, and sometimes finer hairs on the adjacent surface of the base of the leaf: also more or less pubescent

on the face of the base of the leaf. Most important distinguishing characters the shape of the internodes, nodes and buds.

D-109.—Habit inclining to recumbent. Length medium to long. Diameter medium. Shape of the stalk curved. Color dark purple to greenish-red; abundantly glaucous. Internodes medium to long, slightly flattened; typically tumid, especially so in the lower part, making them sub-conical; furrow shallow or imperceptible. Nodes medium to small, regular in shape; usually as dark or darker than the internodes, when on the lower part of the stalk, but lighter and greener above; two or three rows of rudimentary roots. Buds nearly all having started to expand on the standing stalk; scales usually lighter in color than the shoot; the young buds typically plump, fairly uniform and ovate to oval in outline; margin narrow, and in the young buds, semi-elliptical at the point; having inconspicuous lobes on the sides; slightly bearded at the tip. Foliage abundant, dark in color. Leaf medium to broad, medium length, gradually tapering into a fine point. Leaf-sheath compressed laterally at the throat, reddish in color, very glaucous; auricles medium size, sometimes long-pointed on one side of the stalk; ligula short, with the upper edge more or less pointed in the center. Vestiture of leaf-sheath a few setae in a narrow line on the back. Vestiture of throat of sheath soft hairs on the auricles and adjacent edges of the leaf, and sometimes pubescent on the surface of the base of the leaf blade. Most important distinguishing characters color and the form of the internodes and the buds.

D-625.—Habit erect. Length medium to long. Diameter large. Shape of stalk usually straight. Color light yellowish-green to yellow; reddish brown rings at the upper limit of the nodes, especially on the upper portion of the stalk; the portion of the node below the leaf-scar glaucous. Internodes medium to long, nearly round in cross-section; the sides typically nearly straight but sometimes slightly constricted and sometimes a little tumid on the side opposite the bud; sometimes a little staggered; furrow broad but shallow. Nodes medium to large; the portion above the leaf-scar long and usually as large, or larger, in diameter than the internode above; rudimentary roots rather far apart, in two or three rows; the depressed ring forming the portion below very shallow. Buds large and quite uniform in shape; typically plump and broadly triangular to ovate in outline; margin medium to narrow and conforming to the shape of the bud; often bearded at the apex and barbellate on the sides of the margin. Foliage medium to scant, color medium green. Leaf medium width, medium length, sub-erect, tapering into

a fine point medium abruptly. Leaf-sheath nearly round at the throat; auricles small; ligula medium length, with the upper edge usually rounded, but sometimes slightly pointed, and sometimes slightly depressed in the center. Vestiture of leaf-sheath many soft setae. Vestiture of throat of sheath medium fine hairs on the auricles and adjacent edges of the leaf, and sometimes behind the ligula; sometimes finely pubescent on the face of the base of the leaf. Most important distinguishing characters form and size of the internodes and buds, and the brown ring on the node.

EXPLANATION OF PLATES.

PLATE X.

Fig. 1.—A bud of Yellow Caledonia cane, showing a narrow, uniform margin, without lobes, and a barbate apex. × about 3½.

Fig. 2.—A bud of B 208, showing a margin with large lobes and a barbate apex. × about 3.

Fig. 3.—A bud of the same variety, expanded, showing the globoid point. × about 3.

Fig. 4.—A portion of the leaf-sheath of Cavengerie cane, showing setae. × about 3½.

Fig. 5.—The ciliated leaf-scar, occurring on B 3747, B 1355 and B 1356. × about 3½.

PLATE XI.

Fig. 1.—Otaheite. Distinguished by its somewhat tumid internodes and its sub-eliptical to ovate buds. × about ⅔.

Fig. 2.—Rayada. Distinguished by its stripes and the broadly ovate to ovate-acuminate buds. × about ¾.

PLATE XII.

Fig. 1.—Crystallina. Distinguished by its glaucousness, its typical plump internodes and its broadly ovate-acuminate to triangular buds. × about ¾.

Fig. 2.—Yellow Caledonia. Distinguished by its almost cylindrical internodes and the fine cracks in the epidermis of the internodes. × about ⅗.

PLATE XIII.

Fig. 1.—B 347. Distinguished by its long ovate to oval buds, and the light-colored blotches on the internodes. × about ½.

Fig. 2.—B 3412. Distinguished by the medium thin stalks and the prominant expanded buds. × about ¾.

PLATE XIV.

Fig. 1.—B 208. Distinguished by its plump internodes, the shoulder above the node, and the expanded, globoid buds. × about ⅝.

Fig. 2.—B 6450. Distinguished by the shape of the internodes and the ovate to triangular buds. × about ⅔.

PLATE XV.

Fig. 1.—B 3859. Distinguished by the more or less staggered and tumid internodes and the plump, expanded buds. × about ⅔.

Fig. 2.—B 4596. Distinguished by its straight-sided, almost cylindrical internodes, and the wide margin and large lobes of the buds. × about ⅝.

Plate XVI.

Fig 1.—B 3747. Distinguished by the shape of the internodes and its ciliated leaf-scar. × about 3/5.

Fig. 2.—B 7169. Distinguished by its glossy surface, the almost straight-sided internodes and the regular, ovate to acute buds. × about 3/4.

Plate XVII.

Fig. 1.—B 3405. Distinguished by its slightly tumid to sub-conical internodes and its broadly semi-eliptical to broadly ovate, usually expanded, buds. × about 2/3.

Fig. 2.—D 117. Distinguished by the large nodes, the shape of the internodes and the broadly ovate to triangular buds. × about 2/3.

Plate XVIII.

Fig. 1.—D 109. Distinguished by the tumid or sub-conical internodes and the usually expanded buds. × about 3/5.

Fig. 2.—D 625. Distinguished by the thick, erect-growing stalks, its almost cylindrical internodes, the brown ring on the nodes, and the regular, plump broadly ovate to triangular buds. × about 2/3.

PLATE X.

CHARACTERS OF VARIETIES OF SUGAR CANE.

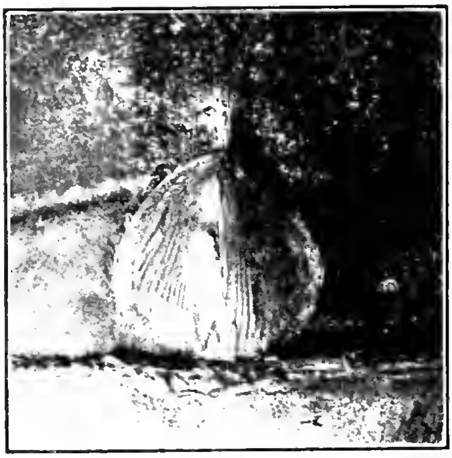

Fig. 1.

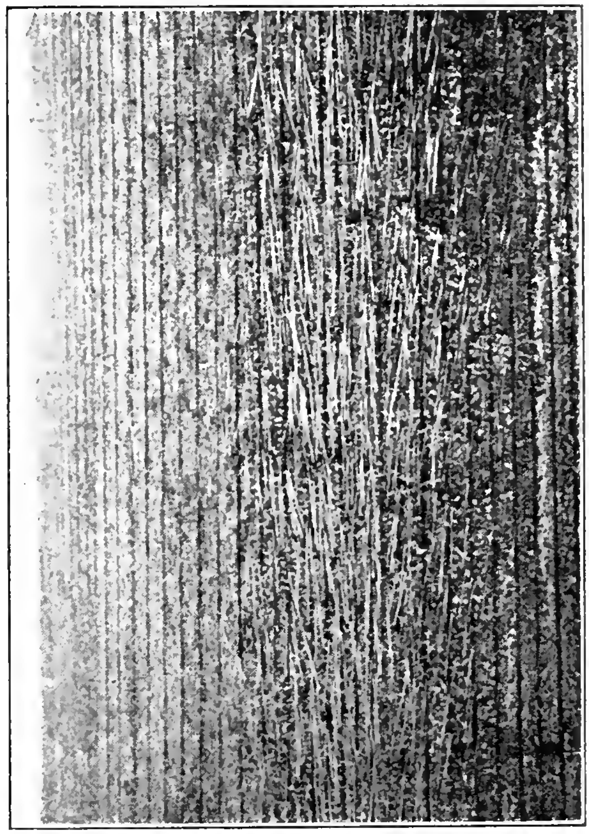

Fig. 4.

Fig. 2.

Fig. 5.

Fig. 3.

PLATE XI.

SUGAR-CANE VARIETIES OF PORTO RICO.

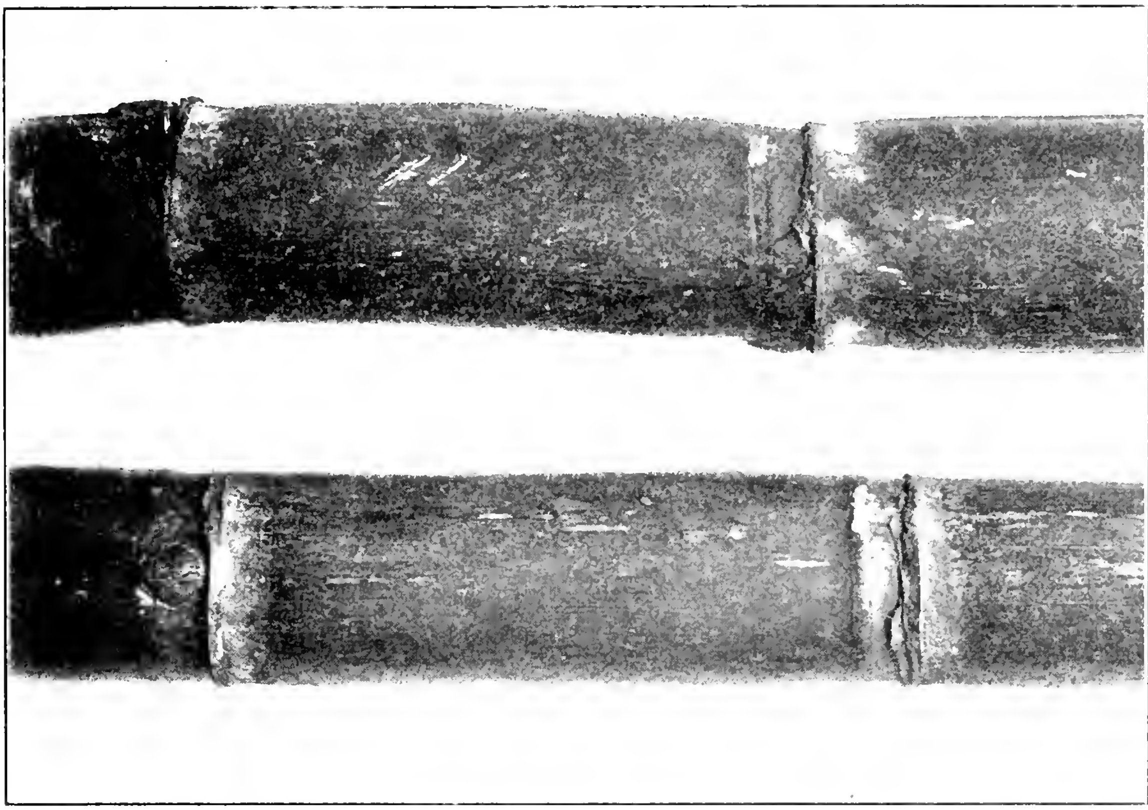

Fig. 2.

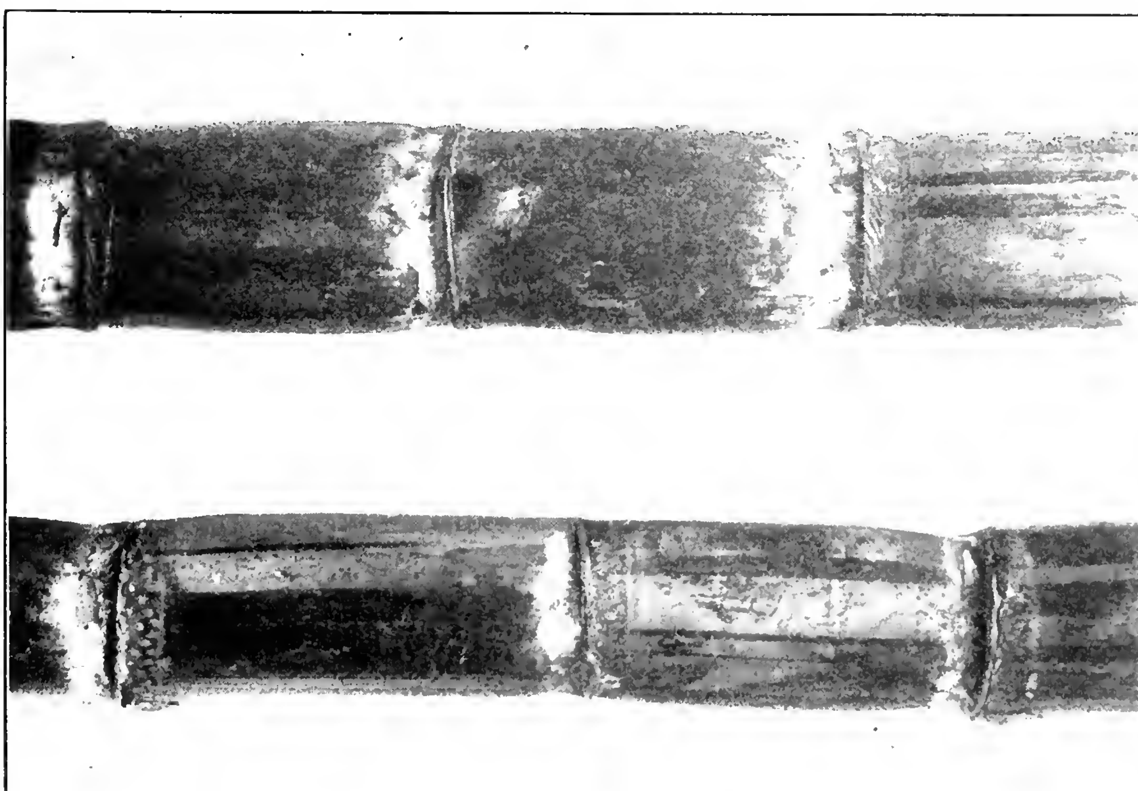

Fig. 1.

PLATE XII.

SUGAR-CANE VARIETIES OF PORTO RICO.

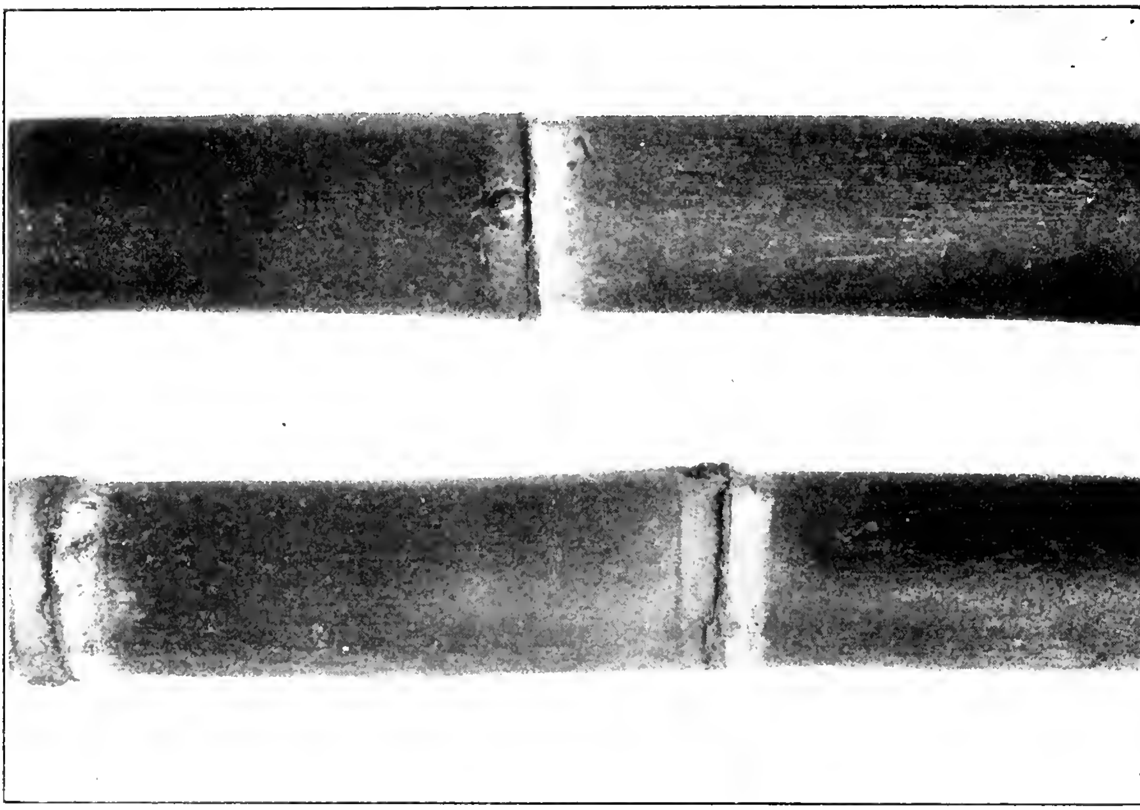

Fig. 2.

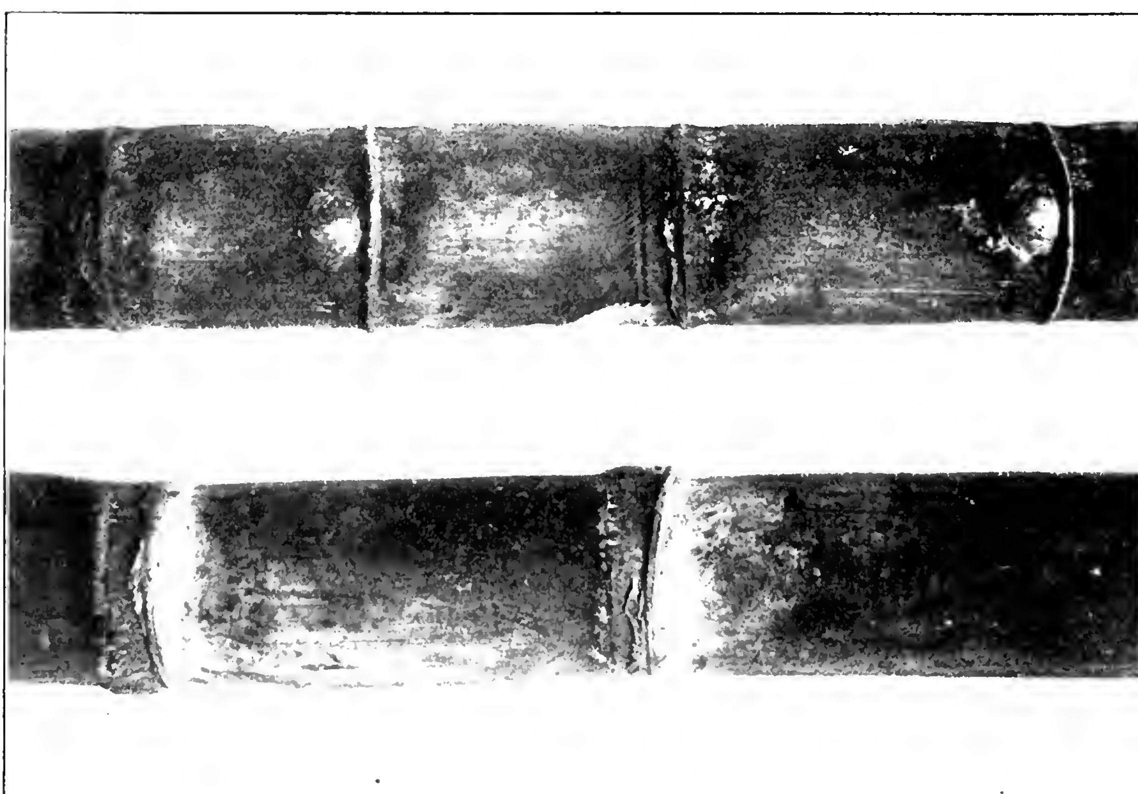

Fig. 1.

PLATE XIII.

SUGAR-CANE VARIETIES OF PORTO RICO.

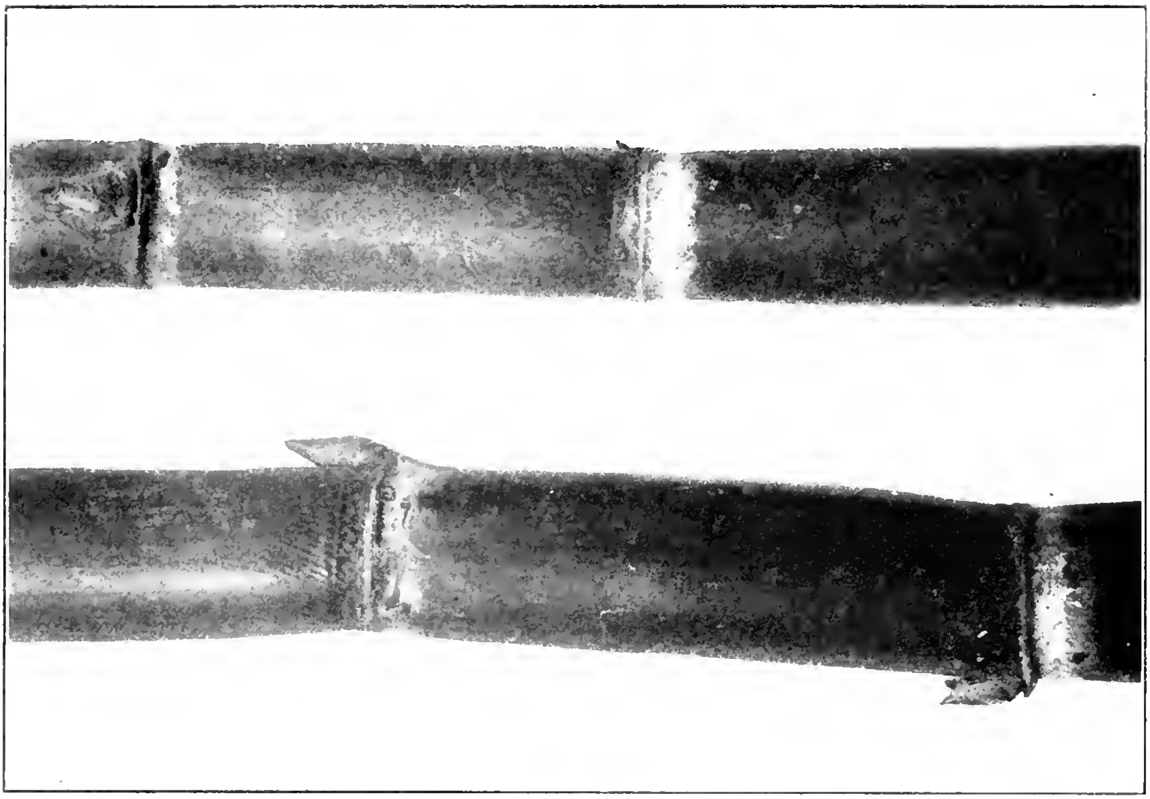

Fig. 2.

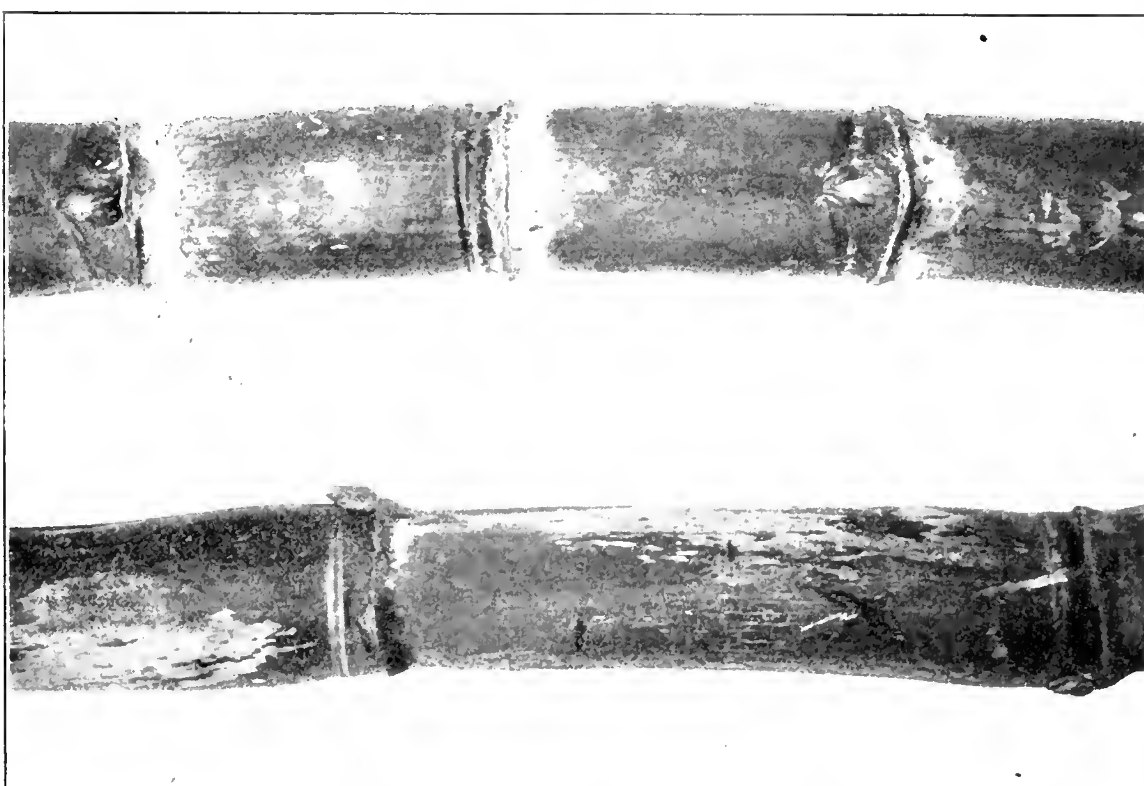

Fig. 1.

PLATE XIV.

SUGAR-CANE VARIETIES OF PORTO RICO.

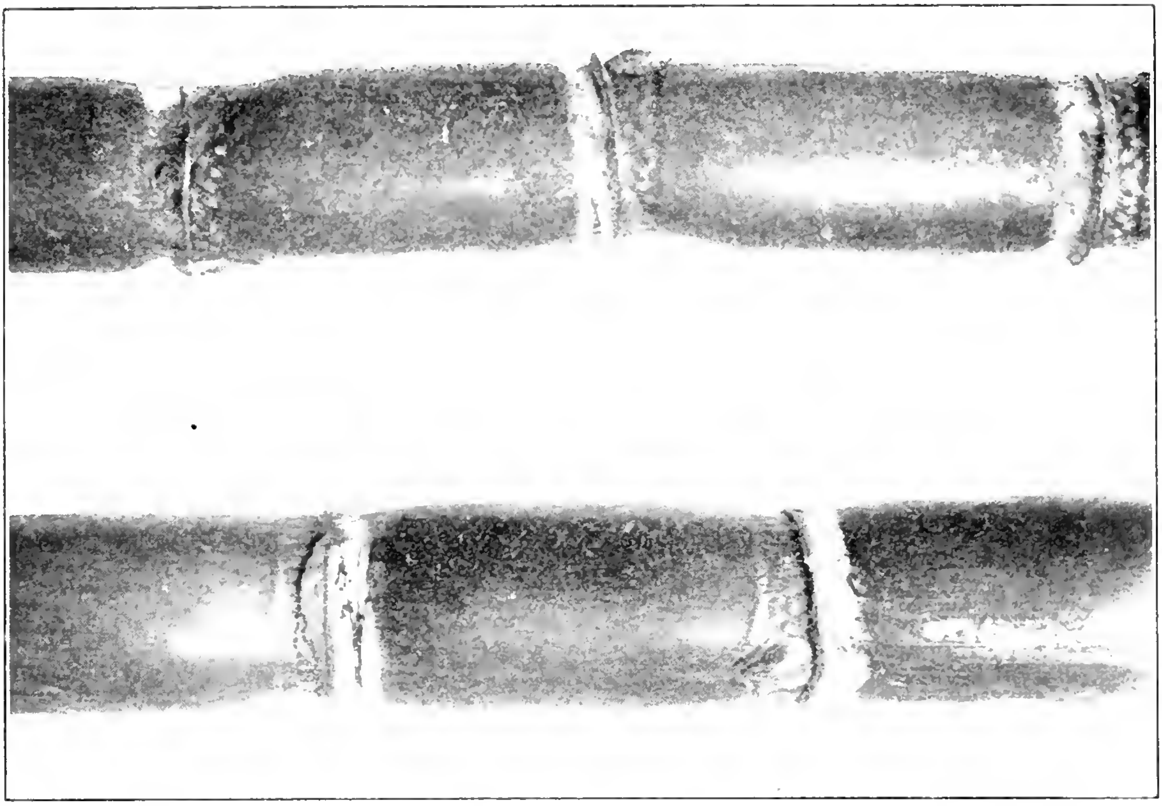

Fig. 2.

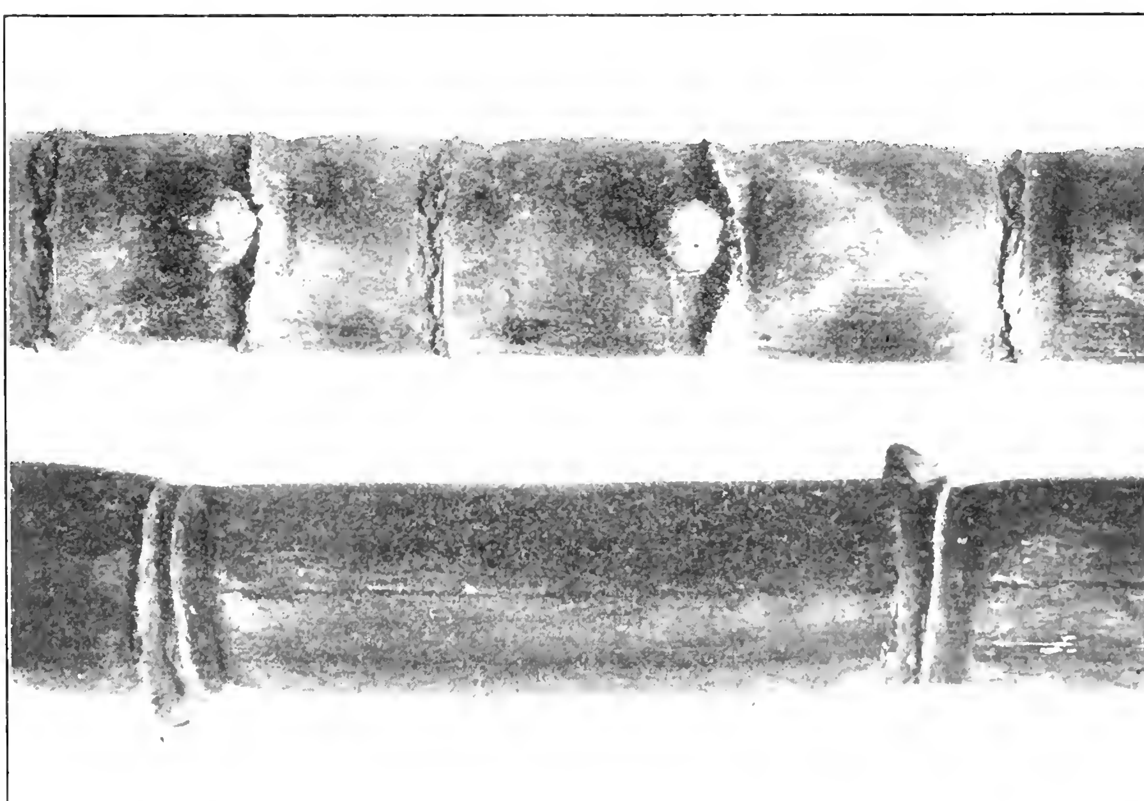

Fig. 1.

PLATE XV.

SUGAR-CANE VARIETIES OF PORTO RICO.

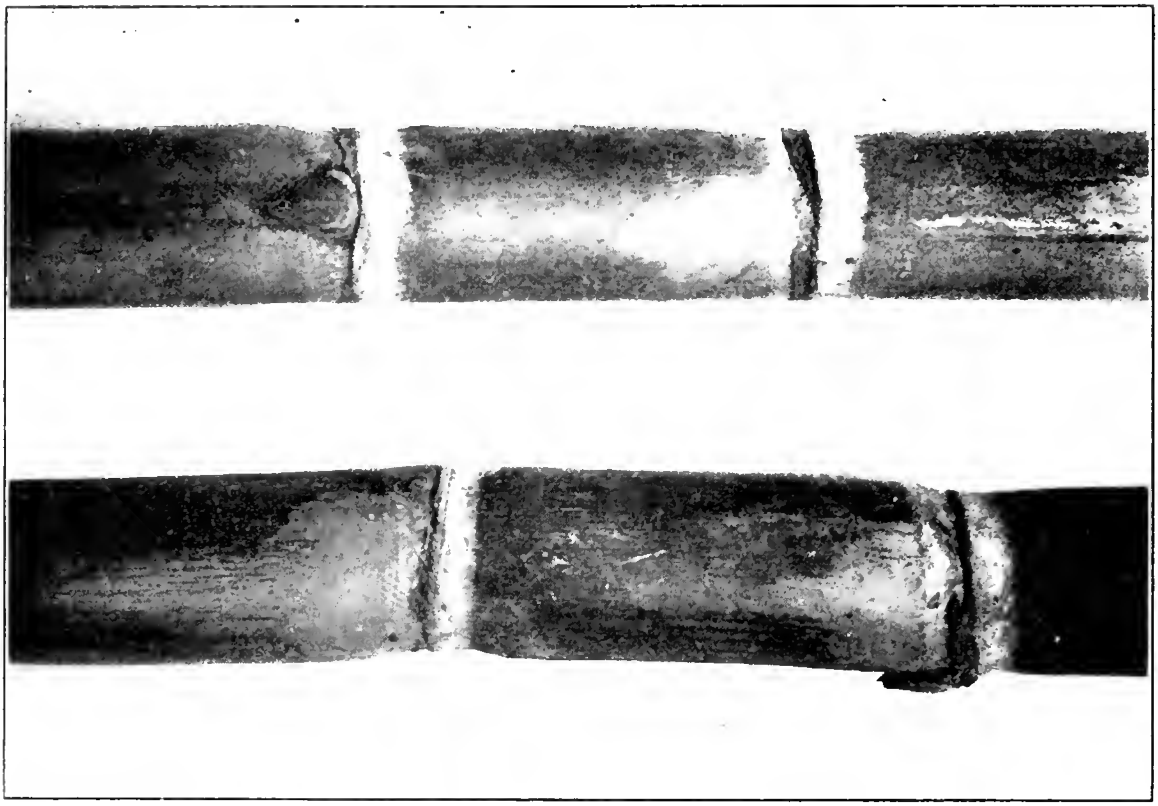

Fig. 2.

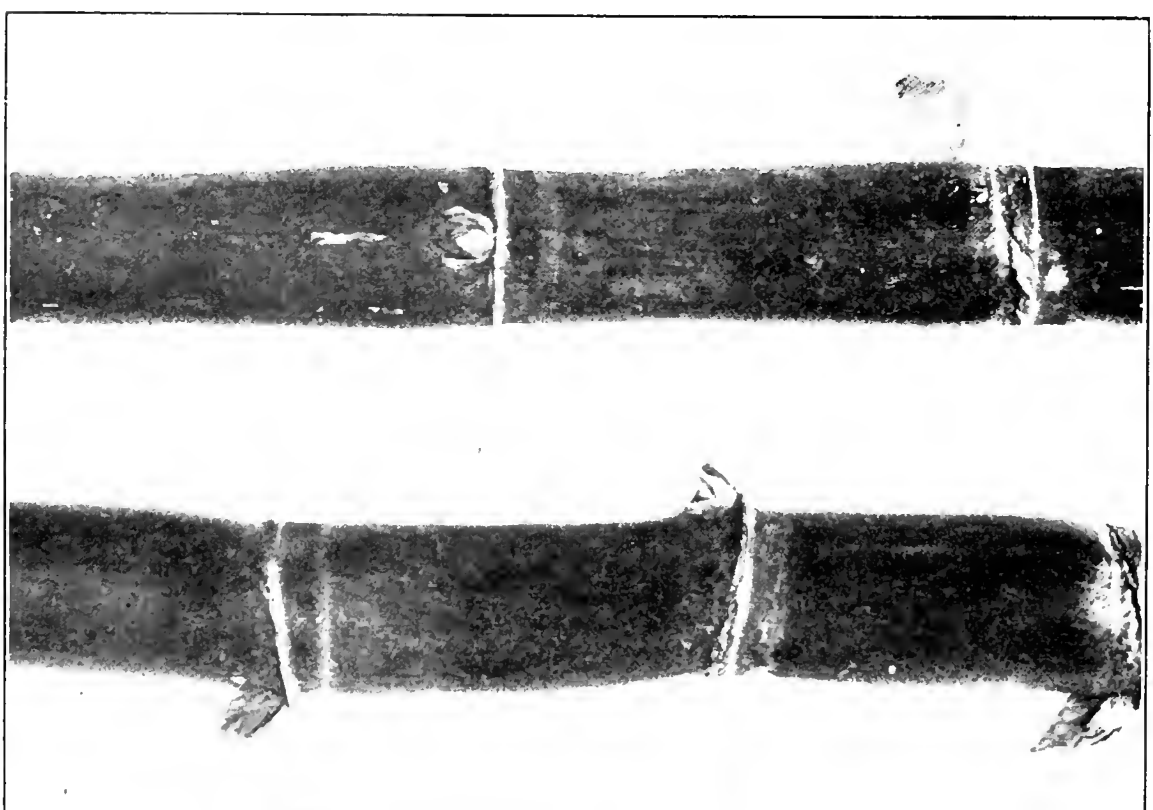

Fig. 1.

PLATE XVI.

SUGAR-CANE VARIETIES OF PORTO RICO.

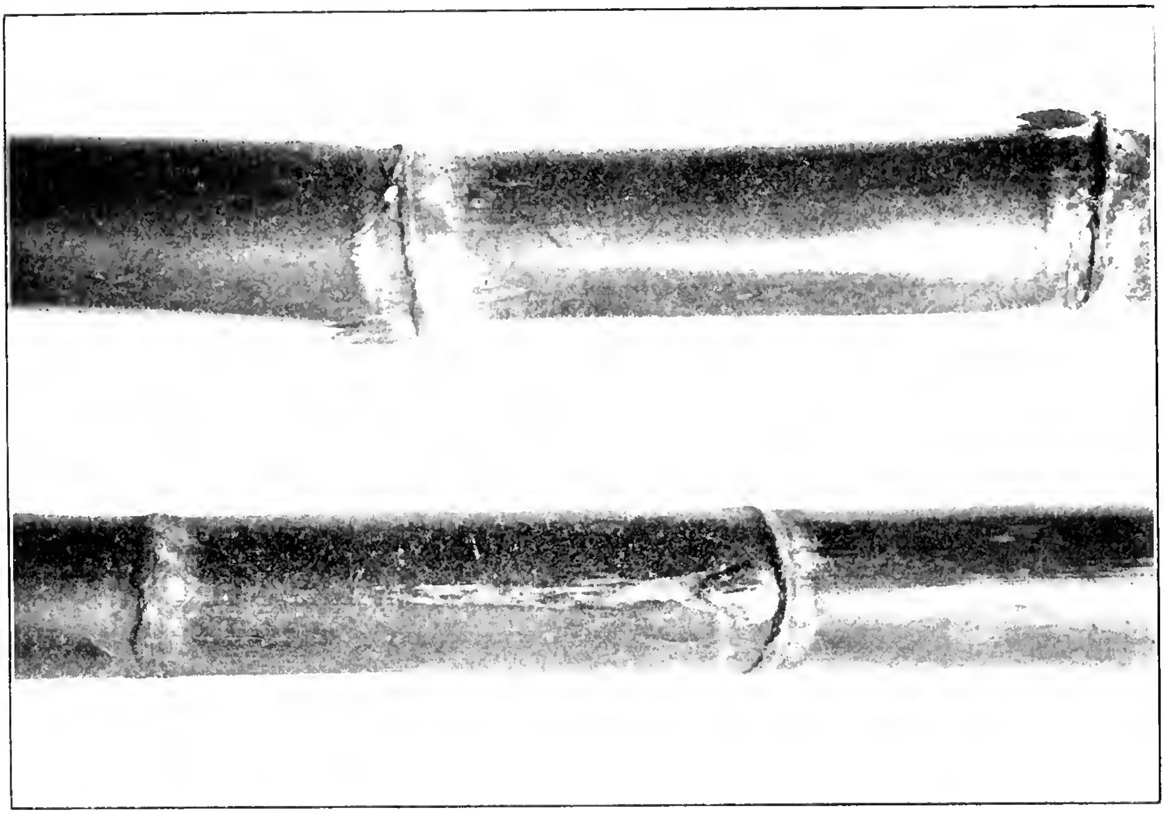

Fig. 2.

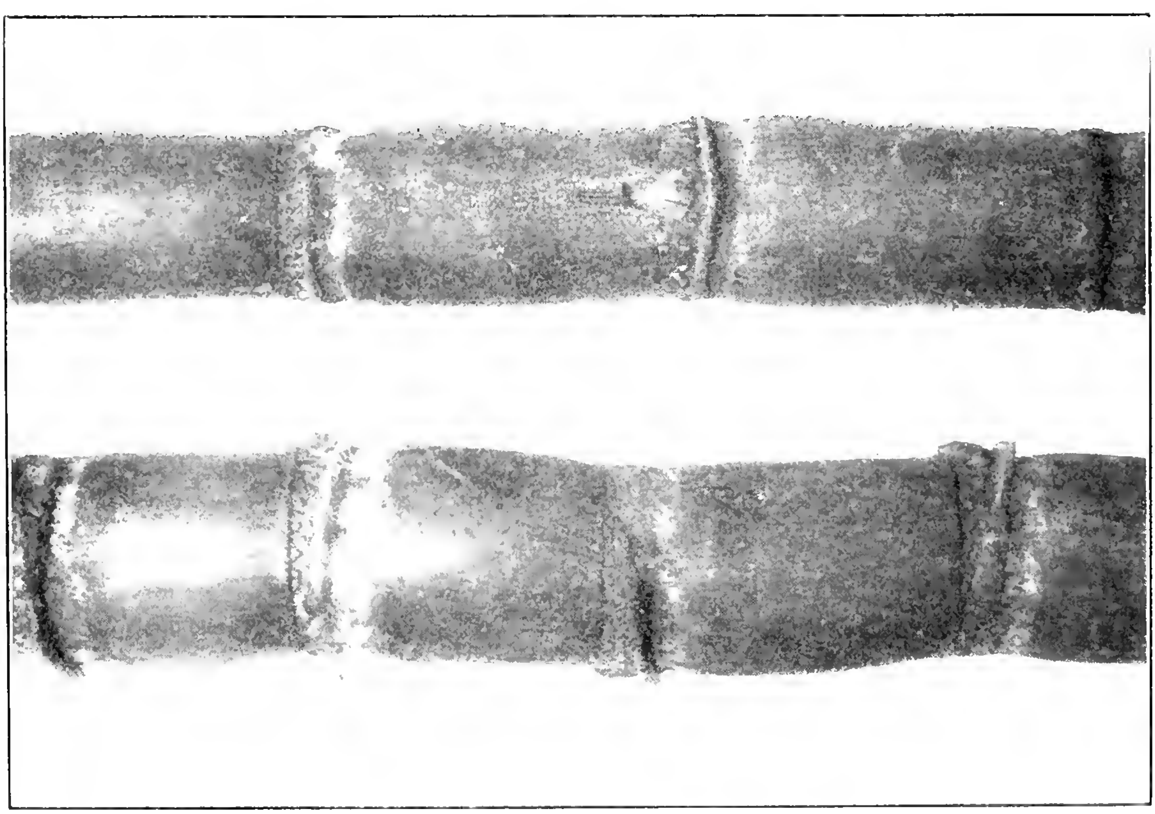

Fig. 1.

PLATE XVII.

SUGAR-CANE VARIETIES OF PORTO RICO.

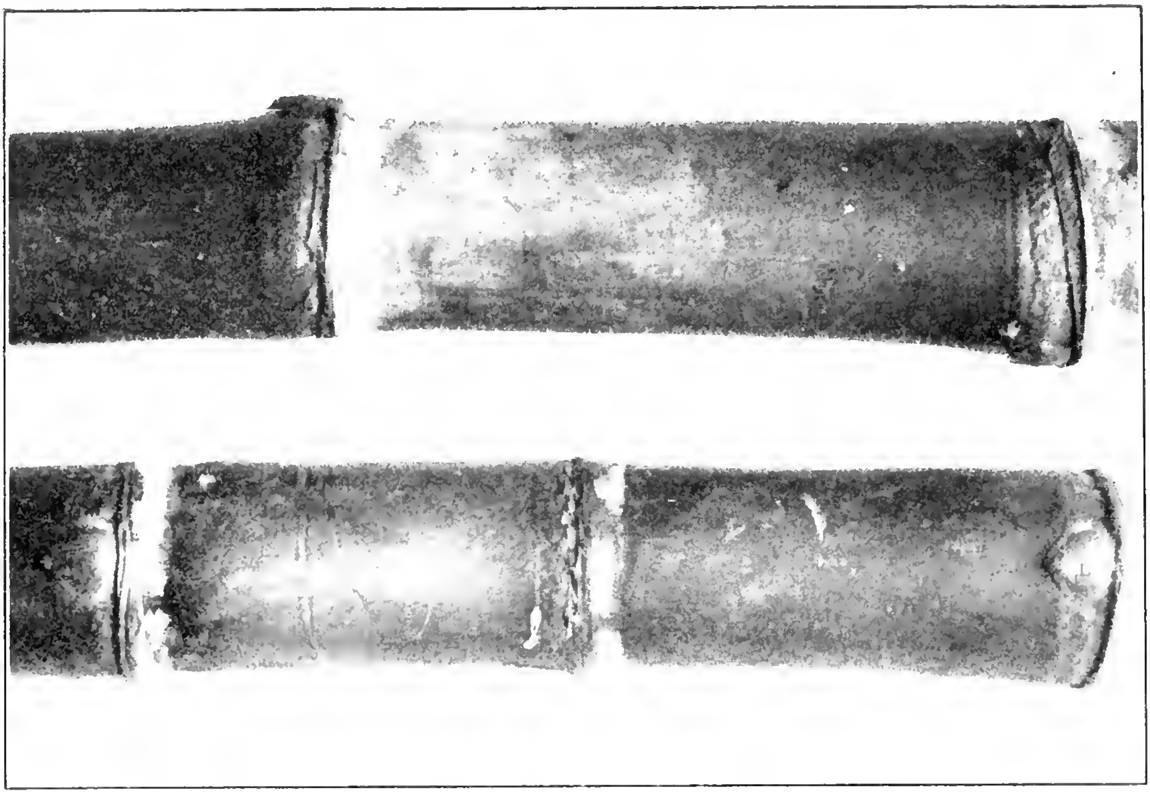

Fig. 2.

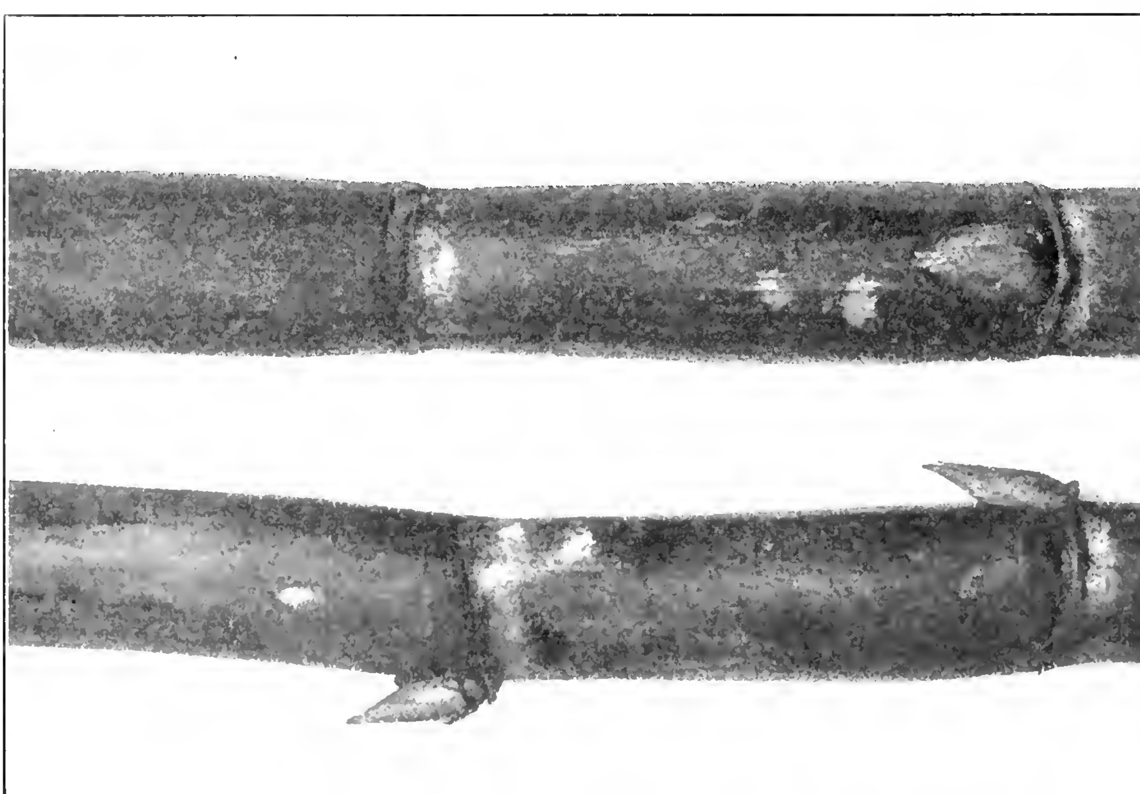

Fig. 1.

PLATE XVIII.

SUGAR-CANE VARIETIES OF PORTO RICO.

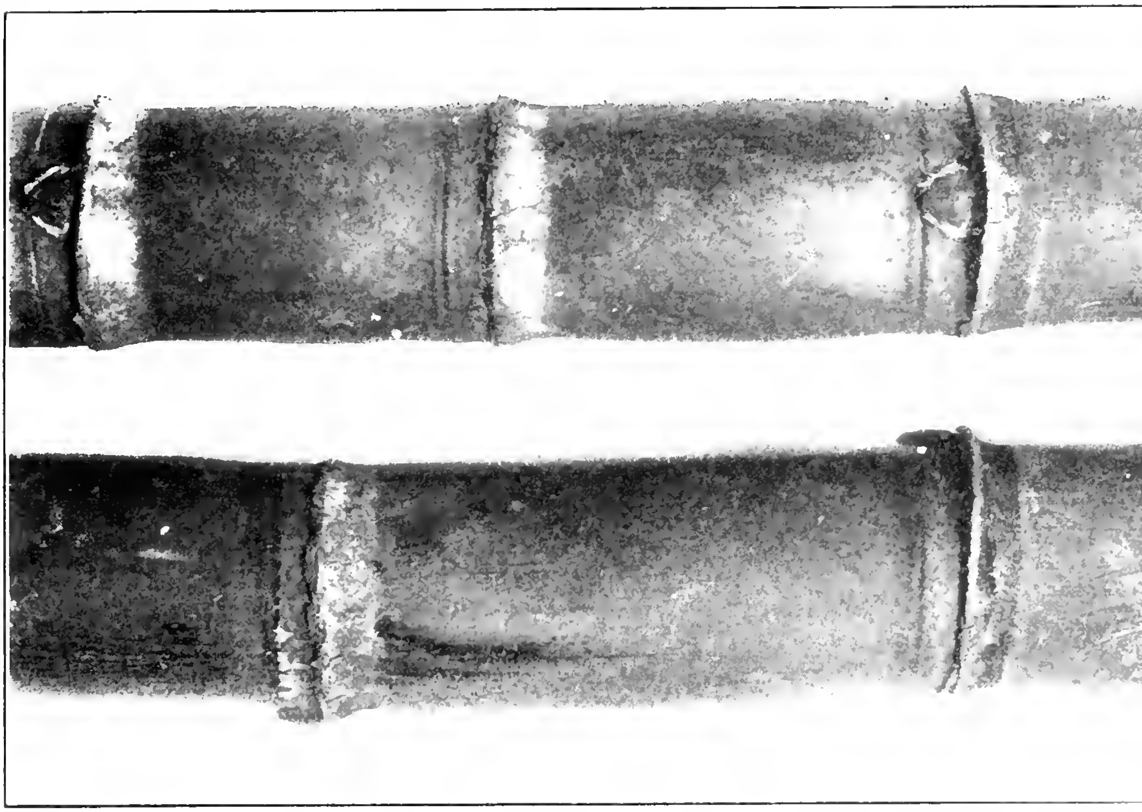

Fig. 2.

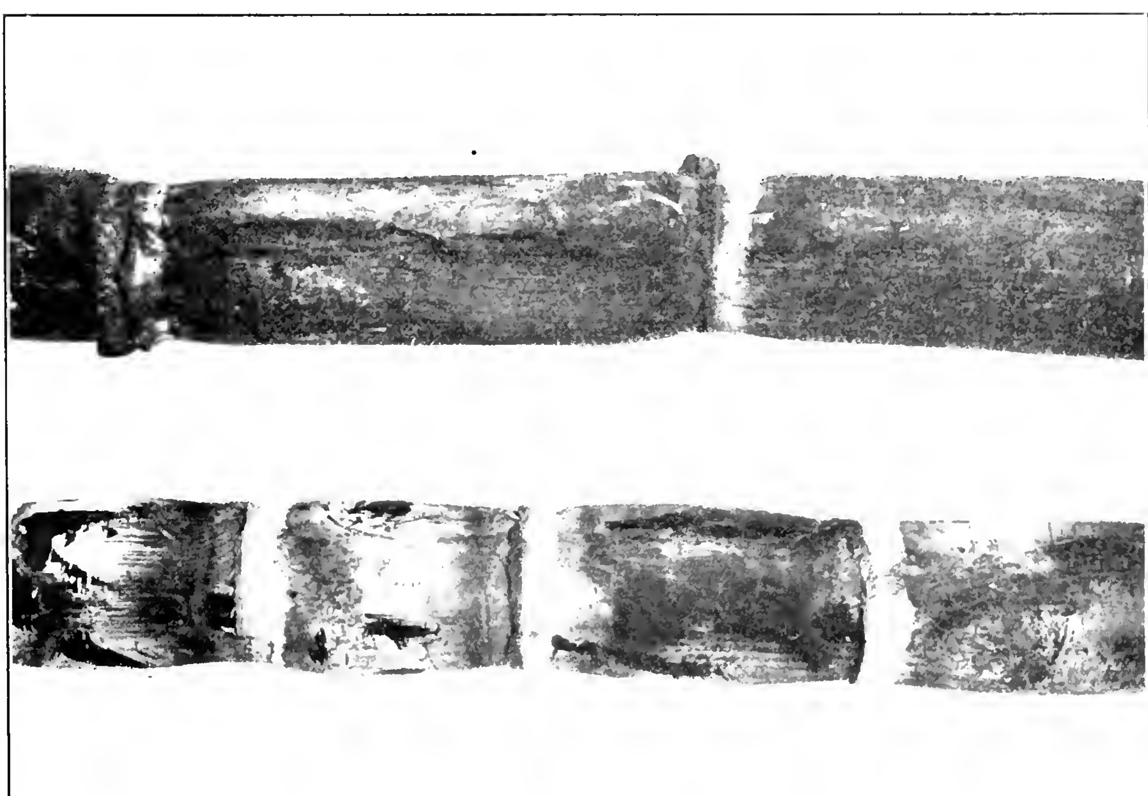

Fig. 1.

THE WHITE-GRUBS INJURING THE SUGAR CANE IN PORTO RICO.

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1. LIFE-HISTORIES OF MAY-BEETLES—Continued.

By EUGENE G. SMYTH, Acting Entomologist, Insular Experiment Station.

THE SUGAR CANE WHITE-GRUB—Continued.

INFECTION BY THE METARRHIZIUM FUNGUS.

Infection of *Phyllophaga vandinei* n. sp.* in the experimental jars and boxes by the green muscardine fungus, *Metarrhizium anisopliae* (also known as *Entomopthora anisopliae* and *Isaria destructor*), has been noted of every stage except the pupa. The number of specimens that developed the disease, as compared to the total number kept in confinement under close observation, may be summed up in the following table:

Of 853 adults kept in confinement, 81 became infected, or 9.5 per cent.
Of 1,502 eggs kept in confinement, 10 became infected, or .66 per cent.
Of 852 grubs, 1st instar in confinement, 3 became infected, or .36 per cent.
Of 209 grubs, 2d instar in confinement, 3 became infected, or 1.43 per cent.
Of 117 grubs, 3d instar in confinement, 16 became infected, or 13.67 per cent.
Of 48 pupae kept in confinement, none became infected.

The majority of diseased specimens were adults, which is possibly accounted for by the fact that they, moving about freely in the jars, are more apt to transmit the disease from one individual to another than are larvae or eggs.

The stage in which the highest per cent of individuals became infected was the third instar of the grub, in which infection was necessarily contracted from the soil, which is believed to have contained large numbers of spores.

The degree of susceptibility to infection by the disease was, among the immature stages of the beetle, lowest in the pupal stage and highest in the third instar of the larval stage.

The following conclusions have been reached regarding attack of

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* The habits of this species, and suggestions for control, were discussed in the Third Report of the Board of Commissioners of Agriculture of Porto Rico (pp. 42–47), under the name *"Lachnosterna grande,"* and its life-cycle (except pre-oviposition) given in the Fourth Report (p. 47) under the same name.

May-beetles by *Metarrhizium*, as result of the behavior of the fungus in its attack on *Phyllophaga vandinei*:

(1) Judging from its behavior in jars containing numbers of adults confined together, the fungus had every appearance of being transmittable.

(2) In jars containing only two adults, the fungus gave no indication of being transmittable. Out of 25 such jars in which at least one beetle contracted the disease, in only two (or 8 per cent of them) did both beetles of a pair become infected.

(3) In the case of grubs, transmission of the fungus from one grub to another was not possible, since practically all of the grubs that became infected were reared in individual boxes. Infection must have taken place through the soil.

(4) Comparing the infection of adults and of third instar grubs, it appears that a higher degree of infectation may be brought about through the medium of infection from the soil than through transmission of the disease by contact. There is no proof that transmission by contact ever takes place.

(5) Attempts to artificially infect grubs by the introduction of dry spores into rearing boxes were unsuccessful.

(6) Since all infected specimens, when found, were at once removed from rearing boxes and preserved, artificial increase of the number of spores in the soil used was certainly very limited. It obviously required a very small quantity of the spores to infect a large number of grubs and beetles.

(7) Spores were at no time introduced into the soil by the writer, so must have existed naturally in the soils of the district where the experiments were made. This was proved by the finding, outside the insectary, of the following insects infected with the fungus:

Aphodius sp., two adults under manure in stock lot.
Canthon sp., a dozen or more adults in an outdoor cage.
Strategus titanus, one adult in an outdoor cage.
Ligyrus tumulosus, several adults in an outdoor cage.
Phytalus insularis, several grubs in an outdoor cage.

(The last four species were in separate cages, removed some feet apart, with no intermixing of soil from one to another.)

(8) Shipments of *Metarrhizium* spores were made by Mr. Van Dine, in 1911 and 1912, to Mr. T. C. Murphy of Guánica Centrale, who propagated the fungus extensively on May-beetles in the same *hacienda* (Santa Rita) where the writer's experiments were conducted. Later shipments of spores to the same district were also made by the pathologists of the Station, Mr. Johnson and Mr. Stevenson. This may have accounted for the prevalence of the disease in the insectary.

(9) Neither in grubs nor adults was there, ordinarily, any sickness or other visible abnormal condition immediately preceding death. Often grubs in perfect condition would succumb to the disease in a week's time or less, making it appear that death was caused by the disease alone.

(10) In some cases infection was aggravated by previous attack of the grub by mites or bacterial disease. In case of the latter, the dead grub usually became only in part infected by the fungus, as though the latter were a saprophyte, whereas in grubs perfectly healthy before infection the entire body became covered with mycelium, and later with spores, following death.

(11) Normally, the disease had the effect of delaying molting, or pupation, thus lengthening the instar. The exceptions were: two grubs in first instar that died respectively four and twenty-six days after hatching from eggs; and six grubs in third instar that died within three months after last molting (one in thirteen days and one in two weeks).

(12) In the case of several grubs that died of this disease, it was noted that the preceding instar was above normal in length, indicating that a rather long period of infection by the disease precedes the outward and visible signs of disease.

Infection of Grubs by Bacterial Disease.

A very high fatality of grubs in the experimental boxes was caused, or had every appearance of being caused, by a bacterial disease that is supposed to be identical with a disease described as *Micrococcus nigrofaciens* by Zae Northrop. (See Technical Bulletin No. 18, Michigan Agr. Sta., entitled, "A Bacterial Disease of June Beetle Larvae, *Lachnosterna* spp.") The symptoms of the disease are a turning black, and final dropping off, of one or more of the legs at the joints, and the appearance on the body or head of black, shining spots, or lesions, which increase slowly in size and may cover considerable portions of the body before death finally ensues. These symptoms, as observed in grubs in rearing boxes at Santa Rita, are identical with those described in the bulletin by Miss Northrup. Further reason for believing the two diseases identical may be found in a paragraph of that bulletin, which states: "One hundred per cent of larvae received from Porto Rico (March, 1914) were more or less infected."

After examination of the breeding notes, a careful compilation was made of the data concerning the infection of sugar cane white-grubs (*P. vandinei*) by this disease, and as result it was found that sixty-two grubs were noticeably infected, of which number only three pupated and became adult in spite of the disease. The other fifty-nine died, apparently as a result of the disease.

Only the larval stage is attacked by the disease, eggs, pupae and adults being apparently immune. Of the sixty-two larvae attacked, fifty-nine were in the third instar (which represents 50 per cent of the total number reared), and only three in the second instar. No grubs of the first instar were at any time observed attacked by this disease. This is somewhat at variance with the remark made by Miss Northrup that the younger grups are the more susceptible.

It is notable that at no time were grubs collected in the cane fields, or elsewhere out-of-doors, found affected by this disease. Yet within a few weeks' time after they were placed in the confinement of boxes, the disease would make its appearance on fifty per cent of the grubs. This

may have been due to one or more of three causes: (1) that the soil used in the experiments contained the disease to an extent above normal; (2) that the confinement produced a predisposition to the disease through mechanical injury, since it is supposed to require an abrasion of the skin in order to permit the bacteria to gain access to the grub's body; or (3) that excessive humidity in the boxes was favorable to the progress of the disease.

The fifty-nine grubs that died in experimental boxes apparently as a result of the bacterial disease were divided into four groups, as follows:

(1) Grubs with sure signs of infection, that died while still in the larval stage.

(2) Grubs with lesions, or other signs of the disease, that reached the pupal stage and then died.

(3) Grubs with lesions or other signs of disease that died, but were also infected with *Metarrhizium* fungus, so that the exact cause of death was uncertain.

(4) Grubs that showed a characteristic blackening of segments after death, but of which no previous symptoms had been noted.

Of these four groups, forty-five of the grubs fell in the first, four in the second, six in the third, and four in the fourth.

Some idea of the progress of this disease, prior to death of the grub, may be gained by the following records of ten individual infected grubs:

(1) Jan. 18.—Lesion of 1½ mm. on side.
Feb. 3.—Pupating; lesion is 2 mm. across.
Feb. 8.—Pupated. (Adult issued March 3.)

(2) Feb. 17.—Has black lesion 1½ mm. in diameter.
May 26.—Same lesion now 2 mm. across; another lesion of 7 mm. Grub died as result of these.

(3) June 2.—Two right legs with bacterial lesions.
June 30.—Three legs on opposite side now infected.
Aug. 14.—Grub died; discolored.

(4) June 2.—Right middle leg infected at tip.
June 30.—Same leg half off.
July 3.—Tip of left middle leg infected.
July 7.—Tips of all legs but one infected.
July 26.—Preparing to pupate; sickly.
Aug. 5.—Died without pupating; infected with *Metarrhizium*.

(5) May 3.—Has one leg with bacterial lesion.
June 7.—Pupated; pupa with tarsi of that leg missing.
June 25.—Pupa died.

(6) Feb. 5.—Has four small black lesions.
May 26.—Three legs infected, a fourth half eaten off; a lesion of 2½ mm.
May 30.—Grub dead, discolored.

(7) Feb. 18.—A lesion 1½ mm. one one side.
May 26.—Lesion is 2 mm. in diameter.

June 30.—Two more lesions of 2 mm. on other side.
Aug. 5.—Dead and black, including head.
(8) May 26.—Tip of one leg with bacterial lesion.
July 7.—Half of same leg off from disease.
Aug. 21.—Grub dead and discolored.
(9) June 28.—Grub pupating; left middle leg eaten off.
July 2.—Pupa has a left leg, but small.
July 20.—Adult issued, imperfect; died.
(10) June 27.—Grub has lesion on head; two back legs infected (2d instar).
July 5.—Has molted to third instar; two back legs smaller.
Dec. 11.—Grub dead; discolored.

This bacterial disease can hardly be considered as possessing any great possibilities as a means of artificial control of white-grubs, for as seen by the observations cited above, its action in producing death of the grub is slow, requiring in some cases months, under conditions that may be considered ideal for its development. Whether it ever produces fatality of grubs on a large scale in the fields in Porto Rico, at such times as during periods of heavy rainfall, as it is credited with doing in some sections of the United States, is a question open to further investigation.

THE COMMON WHITE-GRUB.

Phyllophaga portoricensis N. SP.*

This species is the eastern analogue of *P. vandinei* occurring at the western end of the Island. Its distribution covers approximately the eastern two-thirds of the Island, being defined in the west by a line running more or less north and south through the towns of Vega Baja on the north coast and Ponce on the south. So far as at present known, its eastern limit on the Island is defined by the east coast. Specimens that have been recently collected on the Island of Vieques, adjoining Porto Rico to the east, appear to belong to this species, so far as genital characters show, though being somewhat larger and lighter in color.

In spite of its wider distribution, this species has not gained as a pest the prominence of the preceding. Damage by it, while most accentuated in the sugar plantations, is by no means confined to them. Its grub is particularly injurious in coffee groves and pineapple plantations. As pines are usually not plowed up until some time after the main crop is harvested, damage from white-grubs may often go unnoticed, or be attributed to poor soil. We have received fre-

* This species has been mentioned, as a supposed variety of *P. vandinei*, under the name of "*Lachnosterna grande* (northern form)," in the Fourth Report of the Board of Commissioners of Agriculture of Porto Rico, page 48.

quent reports of pineapple fields turning yellow in spots, and when the plants were uprooted the soil was found to contain many white-grubs, which turned out to be the larvae of this species. Coffee groves are subject to attack of this May-beetle due to the fact that they are grown under shade of certain forest trees, the foliage of which is much relished by the beetles. After feeding, the beetles descend to the coffee trees beneath the larger shade trees, burrow down into the soil in great numbers at their bases and there deposit the eggs. Naturally, the eggs are found, and the white-grubs that hatch from them do the damage, in whatever locations the beetles descend into the ground. One of the principal shade trees of coffee is the "guamá" (*Inga laurina*), and its foliage is often badly damaged by May-beetles of this species. Mr. Van Dine in a note of April 27, 1912, reports the finding of seventy-four May-beetles at the base of a "guamá" tree in a coffee grove, and one hundred and sixteen beetles at the base of one coffee tree near by. It is not uncommon to find thirty or more May-beetles of this species at the base of a coffee tree. The beetles do not feed upon the coffee foliage, but that fact does not, however, prevent the larvae from attacking the coffee roots.

In sugar plantations, this species has been known to do local damage, sometimes even extensive damage, particularly in the Fortuna and Aguirre districts, and at Humacao, Fajardo, and Canóvanas. No doubt there has been damage in other districts, not so far reported. Outbreaks to an injurious extent seem however to be sporadic, and in none of the infested districts mentioned has attack been so severe as to necessitate the continued employment of women and boys to gather the grubs and beetles, as is done in the Guánica district in the case of the preceding species.

THE BEETLE.

The adult very closely resembles that of the preceding species, but is usually somewhat greater in size (averaging 1 to 2 millimeters more in length), darker in color, and with the surface somewhat polished. In these characters it varies greatly. It is at once distinguishable, in the male, by the sexual characters given in the table; i. e., in the adnate armatures of the male genitalia being spatulate at the tip where in *P. vandinei* they are bifurcate.

Like the preceding, the adult of this species may be found in the field during eight to nine months of the year. It appears the latter part of February to early March, and disappears during November. Stragglers are occasionally found in the winter months.

While the life-history of *Phyllophaga portoricensis* has not been studied to the extent and with the thoroughness of the preceding species, such studies as have been made clearly indicate that the entire generation of the species is passed in one year, and that there is sufficient variability in the length of life-cycle to give rise to a considerable overlapping of broods, if indeed the species may be said to have broods. The seasons of appearance in abundance seem to depend largely upon conditions of rainfall, which would indicate that the stage of the life-cycle displaying the greatest variation in length, next to the third instar of the grub, is the period during which the newly issued adult is in the pupal cell in the soil, awaiting the proper soil conditions (i. e., of moisture) to dig to the surface and emerge for feeding and egg laying.

A single individual of the species was reared through from egg to adult, requiring for the transformation (from date of laying of egg to date of issuing of adult) two hundred and seventy-six and a half days.

The average time required to undergo these transformations, found by adding together the averages for the several stages of the insect, each secured from a number of records, was 296½ days; the maximum duration, by adding together the maximums of each stage, 343 days; the minimum, 268 days. Reduced to months, these figures show an average egg-to-adult period of approximately 10 months, a maximum of 11½ months, and a minimum somewhat under 9 months. If larger numbers of individuals had been reared through the various stages, the latitude of variation would undoubtedly have been increased.

The Egg Stage.

The description of the egg and the method of laying given for the sugar cane white-grub (*P. vandinei*) will serve equally well for this one.

The average length of the egg stage (from date of laying to date of hatching), from records of the hatching of fifty-four eggs kept in confinement, was computed to be 13½ days, with a maximum period of 16 days and a minimum of 12 days. The length of this stage is practically the same as for *P. vandinei*.

The White-Grub, or Larval Stage.

The average duration of the larval stage of *P. portoricensis*, obtained by adding the average lengths of the three instars, proved

to be 262 days, which lacks four and a half days of being the same as the recorded average duration of the larval stage of *P. vandinei.*

The lengths of larval stages of two individuals reared through from egg to pupa were, respectively, 242 and 252 days, both below the average for the species.

The First Instar.—This instar of the grub, computed from six records, had an average duration of 32 days, a maximum of 40 days, and a minimum of 26 days. During this instar the grub increases in length from about 6–7 millimeters, when first hatched, to 18 or 19 millimeters at the end of the instar. The breadth of head varies from 1.9 to 2.1 millimeters.

The Second Instar.—This, computed also from observations of six individuals, had an average duration of 61 days, a maximum of 93 days, and a minimum of 43 days, which makes the second instar of the grub of this species appear to be much longer than the corresponding instar of the sugar cane white-grub. This is due to the small number of individual records upon which the average is based, two of the six having required in excess of two months (one of them over three months) to pass the instar, which is abnormally long. True averages can be secured only from large numbers of observations, which will require additional study in the case of this species. The average length of instar from four records not exceeding two months in length was 50 days, which is nearer a correct average.

In length the grub increases, during the second instar, from about 18 to 30 millimeters, and the head varies in breadth from 3.3 to 3.6 millimeters.

The Third Instar.—This instar of the grub, as in the case of the preceding species, is taken as including the pre-pupal stage and is figured as the time elapsing between the second molt and the date of pupation. The pre-pupal stage seldom exceeds a week in any of the Porto Rican species of *Phyllophaga.*

The average duration of the third instar, from records of two reared grubs, was 169 days. The time required by each of the grubs was respectively, 164 and 174 days. To gain accurate knowledge of the average duration of this instar will require the rearing of additional grubs in confinement.

The length of grub increases in the third instar from about 30 to 46 millimeters, and the head varies from 5.5 to 6.2 millimeters in breadth. The average breadth of head, computed from seventeen grubs of an average length of 39 millimeters, was 5.78 millimeters.

Pupa, and Pre-emergence of Adult.

The length of duration of the pupal stage of six individuals, was observed and recorded, the average from them being 20.9 days. The maximum was 23 days, the minimum 19 days. The average measurements, from nine pupae, were as follows: length, 27.72 mm.; width at middle, 12.14 mm.; breadth of head, 6.8 mm. It will be seen from these figures that the pupa, like the adult, is somewhat larger in size than that of *P. vandinei.*

We have not as yet secured figures to show the average length of time spent by the adult of this species in the pupal cell, following its issuing from the pupa, before it digs to the surface of the ground. In all probability the time varies from two weeks to a month or more, depending both upon the season of year and the moisture content of the soil. During the winter months the beetle might be expected to spend as much as two or three months in the pupal cell before digging to the surface.

Feeding Habits of Adult.

The feeding habits of adults of this species, and their preferences as to food plants, correspond exactly with those of its near ally, *P. vandinei.* The beetles feed upon the foliage of a rather wide range of plants, but show decided preference for certain species. Some of these, as for instance, the banana, casuarina, or flamboyant trees, may be almost stripped of foliage by the beetles. Other trees, of larger size or with heavier foliage, such as the almendro, guamá, coconut, breadfruit and trumpet tree, may have the foliage badly eaten, but do not show the injury so much as do the species first named. Some other trees observed or reported to be fed upon to an injurious extent by May-beetles are: bamboo (*Bambusa vulgaris*), avocado (*Persea gratissima*), achiote (*Bixa orellana*), cacao (*Theobroma cacao*), guano (*Ochroma lagopus*), roseapple (*Jambosa jambos*), mango (*Mangifera indica*), and mamey (*Mammea americana*), though it has not been definitely ascertained in every instance whether the species doing the damage is this one.

Besides the trees named above, and those previously mentioned of *P. vandinei*, the following plants are fed upon to some extent by this species: *Ficus laevigata, Cordia corymbosa, Cordia borinquensis, Albizzia lebbek* and the corozo palm (*Acrocomia media*). Grasses, aside from cane, are not as a general rule eaten. Sugar-cane foliage, though sometimes showing injury from their feeding, is not as a usual thing noticeably damaged, except where other and more palatable foliage is not near at hand.

A strange thing regarding the feeding habits of this species, which has been noted, is that the adults are often found in abundance in the soil at the bases of trees and weeds upon which they do not feed, such as coffee or young citrus trees, or beneath the wild berengena (*Solanum torvum*), while on the other hand they are seldom found at the bases of certain trees the foliage of which they are very fond of, such as banana and coconut trees. This is not due to a deliberate choice of the beetles as to the kind of roots among which to deposit their eggs, but is explained by the fact that the beetles, before retiring to the soil for the day after feeding, take flight and alight upon small trees or weeds, or upon any upright object affording them good foot purchase, down which they crawl to the soil and enter it. Their holes are thus often found around the bases of posts and dead weeds. Banana trees are too smooth to offer good foot purchase, hence are not settled upon; and coconut palms are provided with a heavy abutment of closely interwoven roots at the base that prevent the beetles from reaching the ground from them.

Among trees and plants that are much fed upon by adults of *Phyllophaga citri*, but are shunned by this species, may be mentioned orange, grape-fruit, Acalypha, Grevillea, guava, Lantana, Miconia, Clidemia, Triumfetta and Urena.

Flight, and Attraction to Light.

The adults of this May-beetle begin coming forth from the soil very soon after dusk, and before actual darkness. As observed in a large outdoor rearing cage during the month of September, the flight may be said to begin at 7:05 P. M. and to last approximately three quarters of an hour.

The following observations were made on an evening of September first: The first beetles appeared above ground and took wing at 7:05 P. M., and they continued to increase in number until 7:20, then remained heavy in flight until 7:35. A few beetles were still flying when observations ceased at 7:50 P. M.

The adults are occasionally attracted to street lights, but only rarely are more than three or four found around a light at one time. On only one occasion has the writer observed an exception to this rule. On April 15 of the present year, around a strong arc light on the *carretera* at Martín Peña, near Río Piedras, over two hundred adults of this species were observed on the pavement, as late as midnight. The probable cause of their abundance was the close proximity of a number of large laurel trees (*Ficus nitida*), upon which the beetles had perhaps been feeding before the turning on of the street lamps.

Copulation and Oviposition.

Copulation takes place immediately upon the cessation of flight, and before feeding begins, normally between 7:30 and 8:15 P. M. In rearing cages it takes place a little earlier, because the flight lasts a shorter length of time than under outdoor conditions. Copulation lasts about thirty minutes.

In the same cage in which the observations on flight were made, the following notes were recorded on an evening of September 2: Quite a number of females were seen at about 8:40 P. M., resting both on the screening and on foliage with the genitalia protruded, in receptive condition. The scarcity of males in the cage accounted for the fact that no copulation was seen. Beetles remain quiet in this position for some minutes before they begin feeding.

Experiments to determine the rate of egg laying of this species are in progress, but have not been completed. The beetle's life above ground is believed to last normally between two and three months, and the egg-laying period to cover in the neighborhood of a month.

Insect Parasitism.

The insect parasites of this May-beetle are identical with those of *P. vandinei*, the Tachinid parasite *Cryptomeigenia aurifacies* Walton being the most useful parasite of adults, and the predacious wire-worm, *Pyrophorus luminosus* Illiger, the most efficient insect enemy of the grubs. These two parasites are very doubtless responsible, in large measure, for the fact that this May-beetle has not caused the disastrous and widespread damage to sugar-cane properties on the north and east coasts that *P. vandinei* has caused in the Guánica district, where neither of the two parasites occur.

Unfortunately, all of our notes relating to the Tachinid parasite *Eutrixoides jonesii* Walton, which were made previous to 1916, fail to indicate what species of *Phyllophaga* were the hosts, since at that time the different species were not distinguished. Necessarily, in the Añasco district the host was one of the two species *P. vandinei* or *P. citri*, or perhaps both, and in the San Juan district must have been either *P. citri* or the present species, if not both. Further observations will be necessary to determine the exact host of this fly.

A Scoliid wasp known as *Elis xanthonotus* Rohwer, the female of which is black with a red spot on the thorox and the male black with yellow cross bands, found very commonly in the fall in the vicinity of Río Piedras, may prove to be a parasite of this species or of *P. citri*, or both. Observations have not thus far revealed the host of the wasp.

The only stages of *P. portoricensis* which have been recorded attacked by the green muscardine fungus are the adult and the third instar of the larva. From the rearing jars and boxes have been taken at different times, altogether, thirteen adults and two grubs attacked by the fungus. The infected adults all came from two jars, each of which contained a good number of specimens, which would seem to indicate that the disease had been communicated from specimen to specimen. The grubs, on the other hand, were from individual boxes, and seem to have contracted the disease from the soil, which, there is reason to believe, contained an abundance of spores of the disease.

Of a total of twenty-four grubs reared past the first instar in confinement, the death of two by the disease represented an infection of 8 per cent. This may have been higher, as grubs were often preserved in alcohol immediately after their death, giving no chance for possible development of spores of the disease.

The per cent of infected adults, to the total number kept in confinement, was still higher than of grubs, but there is no reason to think that such a fatality results from the disease under normal outdoor conditions, since adults showing the disease have been very rarely found in the field.

THE SOUTH COAST WHITE-GRUB.

Phyllophaga guanicana n. sp.*

This species derives its name from the locality in which the type specimens were collected, namely, the Guánica District of the southwest coast of the Island. So far as observations inform us, to date, the species is peculiar to that district.

As a cane pest, it is of comparative unimportance beside the larger species (*P. vandinei*) frequenting that district. Yet it must be included among the pests of sugar cane, since the grubs occur to a certain extent in the cane fields among those of the commoner species. In the nightly collections of May-beetle adults that are made by boys employed for the purpose there is usually to be found, during the months in which the species is active, a small proportion of adults of *P. guanicana*. Actual counts made by the writer in 1914, at weekly or semi-weekly intervals for a period of three months (from the latter

* This species was first mentioned in the Third Report of the Board of Commissioners of Agriculture of Porto Rico (pp. 42–43), under the name of "*Lachnosterna* media," and a summary of its life-cycle (except pre-oviposition) given in the Fourth Report of the Board (p. 47) under the same name.

part of March to the latter part of June), of the entire nightly collections made by the beetle pickers in cane fields, showed that less than one per cent of the May-beetles collected from sugar-cane foliage belonged to this species, the remainder being adults of the common sugar-cane white-grub (*P. vandinci*).

The following table, which is reprinted (revised) from the Third Report of the Board of Commissioners of Agriculture (page 43), gives the actual numbers of beetles of the two species collected on the various nights:

Santa Rita, 1914	*P. guanicana* n. sp.	*P. vandinci* n. sp.
March 30	32	2,968
April 1	12	2,868
" 6	80	3,226
" 13	9	3,188
" 20	40	2,690
" 28	43	2,692
May 17	5	1,279
" 21	12	1,838
June 1	5	2,181
" 8	0	2,384
" 14	1	1,322
" 21	1	1,655
Total	240	28,291

The period of activity of adults of this species is much shorter in duration than that of *P. vandinci.* Appearing at about the same time of the spring, during the latter part of February, it reaches a maximum abundance about middle April to early May, then begins to decrease in numbers and entirely disappears from the fields by the middle of July. In fact, usually only a few are to be found after the middle of June. Having a life-cycle of one year, like *P. vandinci*, it is hard to account for the fact that this species confines its appearance in the adult stage to a short season of the year.

Collections of adults recently made by the writer at Yauco and Santa Rita on May 3 and 4 have shown that this species, outside of cane fields, is equally abundant to *P. vandinci* in the Guánica district in the spring of the year. It was noticeable, however, that the beetles fed largely upon trees and plants not frequented by the larger species. They were particularly abundant on the foliage of *Lantana camara*, the black sage (*Cordia cylindrostachya*), and the ucar tree (*Bucida buceras*), all of which grow in the upland, along fences or scattered through pasture land, and none of which are extensively fed upon by *P. Vandinci.* This leads to the belief that the grub of this species is a sod-frequenting one, preferring dry upland soils, and has not yet taken to the cane fields to any extent.

The Beetle.

This species is very easily distinguished from *P. vandinei* by its smaller size and somewhat darker color. The largest individuals are smaller than the smallest of *P. vandinei*. In length the adult varies from 13 to 17 millimeters, in width from 7 to 8½ millimeters. The average length is about five-eighths of an inch.

The thorax of the beetle, in both sexes, is polished, rich mahogany brown; the elytra are somewhat paler, and polished in the female, but covered with a very fine plumbeous pubescence in the male. The species is very readily distinguished from *P. vandinei* by an examination of the genital organs of either male or female. The characters by which the two are separated are given in the table in the preceding part of this paper, and are quite clearly shown in the plate.

Life-History.

This species has received more study in the immature stages than any other, next to *P. vandinei*, due to its occurrence in the Guánica district, where the South Coast Laboratory was located and where most of the white-grub studies and experiments were conducted. Prior to the work done by the writer, the presence of this species in the Guánica district as distinct from *P. vandinei* seems to have been overlooked, as there is nothing in the earlier notes to indicate that two species occurred together there, and no specimens of the species were in the collection of the Experiment Station.

The life-cycle agrees in a general way with those of the two preceding species in requiring one year. The immature stages require approximately nine months.

For some unaccountable reason, while a large number of the larvae, or grubs, of this May-beetle were reared successfully to past the middle of the third instar, only four individuals were successfully reared to the adult. Two others successfully reached the pupal stage, but a great majority died in the latter part of the third instar. Most of the fatalities occurred within a single week of the summer, and it is believed that the tin boxes, in which the grubs were being reared, were allowed to become too hot from resting against a side of the building exposed to the sun.

Of the four individuals reared through from egg to adult, the shortest required between 226 and 240 days and the longest between 321 and 331 days, which displays a range of duration of from eight to eleven months.

The average duration of the egg-to-adult period, obtained as a

sum of the averages of the egg, pupa and separate instars of the grub, amounted to $268\frac{1}{2}$ days, with a maximum of 336 days and a minimum of 207 days. Reduced to months, this gives an average duration of 9 nine months, a maximum of approximately 11 months, and a minimum of 7 months.

It is notable with regard to the life-cycle of this species that no eggs were laid by adults in confinement later than the middle of May, and that all but nine of the total number of eggs were laid in March and April. This shows that individuals requiring the shorter length of time to pass the immature stages would reach the adult stage during the winter months, and would therefore pass the remaining time in the soil as adults until the regular time of emergence (in the latter part of February and March). Those requiring the maximum of eleven months (which would be very few), even though coming from eggs laid in May, would still reach the adult stage the following April, in sufficient time to mate and lay eggs by May again. This may account for the species having but one brood, appearing wholly between February and June.

The Egg Stage.

The egg of this species does not noticeably differ from that of *P. vandinei* except in being smaller. When first laid it is slender, oblong-oval, about 2 mm. in length by 1.2 mm. in breadth, and opaque pearly white in color. At the end of ten days it is greatly swollen and less opaque in color: it becomes nearly spherical, being then about 2.4 mm. in length by 2.2 mm. in diameter. Just before hatching, the brown mandibles and the segmentation of the young grub become plainly visible through the shell of the egg.

The duration of the egg stage, from an average of 505 eggs whose hatching was observed in confinement, amounted to $13\frac{1}{2}$ days. The maximum duration was 19 days; the minimum, 11 days.

The White-Grub, or Larval Stage.

As in other May-beetles, the larval period of this species includes four distinct stages: the first, second and third instars, and the pre-pupal stage. Between the first and second instars, and again between the second and third instars, there is a molt of the larval skin, following which the head and legs of the grub increase very perceptibly in size. At the end of the pre-pupal stage there is also a molt, to form the pupa. There is no molt between the last instar of the grub and the pre-pupal stage, and the change from one condition to the other is quite gradual. This change in condition does not take place until

a week to ten days immediately preceding the pubation of the grub. In our figures, therefore, the pre-pupal stage is considered as included in the third instar of the grub.

The average duration of larval period from the sum of the average lengths of the three separate instars, was 233 days; the maximum, 295 days; the minimum, 174 days. Reduced to months, this gives an average duration of 7¾ months, a maximum of 9¾ months, and a minimum of 5¾ months.

The average length of the larval stage, obtained from the six individual grubs that successfully reached the pupal stage, was 245 days, which was twelve days in excess of the average for the species. This was due, it is believed, to the fact that the soil in the cage in which these five grubs were reared was allowed to become very dry at times, for periods of weeks, which retarded the growth of the grubs to a marked degree.

The First Instar.—The average duration of this was 24 days, the maximum 35 days, and the minimum 13 days, computed from a total of sixty records of reared grubs.

In measurement, the first-instar grub varies in length from about 5 millimeters, when first hatched from the egg, to a maximum length of 12 or 13 millimeters.

The average diameter of the head, from measurements of thirty-two grubs whose average length was 11.3 millimeters, was found to be 1.33 millimeters.

The Second Instar.—The average duration of the second instar was found to be 31 days, or just a month; the maximum 39 days; the minimum, 23 days. These figures are from the records of thirty-eight individual grubs reared through this instar.

The length of the grub in the second instar increases from 12 or 13 millimeters just following the molt, to a maximum of 20 or 21 millimeters. The average width of head, from measurements of thirty-three grubs whose average length was 15.7 millimeters, was found to be 2.38 millimeters.

The Third Instar.—The average length of the last instar, taken from six grubs that reached the pupal stage, was found to be 178 days; the maximum, 221 days; the minimum, 138 days. Or, reduced to months, the average was 6 months, the maximum 7⅓ months, and the minimum about 4½ months.

In length, the third instar grub increases from about 20 to about 31 or 32 millimeters. The average width of head, from measurements of five grubs whose average length was 25 millimeters, was found to be 4.09 millimeters.

From the above measurements of grubs, it will be seen that larvae of this May-beetle may be at once distinguished from those of *Phyllophaga vandinei,* in whatever instar, by simply measuring the diameter of the head with a sliding callipers. Furthermore, by means of the head measurements and a consideration of the locality, the grubs of any of the five species of May-beetle occurring on the Island may be easily distinguished, one from the other, without the need of laboriously studying minor characters, which at best are variable.

PUPA AND PRE-EMERGENCE OF ADULT.

The length of the pupal stage of *Phyllophaga guanicana* was determined as 22 days, recorded from a single pupa. The measurements of this pupa were as follows: length 18 millimeters; width at middle, 7.9 millimeters.

The pupa may be very readily distinguished from that of *P. vandinei* by its smaller size, and its somewhat darker color.

As has been stated before, the length of time spent by the adult of this species in the pupal chamber before emergence is supposed to very often exceed a month, and may perhaps, in cases where the adult issues during November, approach or even exceed three months. No experiments were conducted to determine this fact. In confinement, however, three adults issued during late November and early December; and it is well known that in the field beetles of this species never emerge from the soil during these months.

FOOD PLANTS OF ADULT.

This species, as was mentioned in the beginning, frequents the dry upland pastures and brush land, and is not often encountered in cane fields. It is natural, then, that its food plants should differ considerably from those most palatable to the sugar-cane May-beetle (*P. vandinei*). Among the few trees upon which both species are known to feed may be mentioned the flamboyant, casuarina, salcilla (*Schrankia portoricensis*), guacima, and tamarind.

Among those trees and bushes which are fed upon peculiarly by this species, and are rarely or never eaten by the sugar-cane May-beetle, are the guava (*Psidium guayava*), the ucar tree (*Bucida buceras*), the black sage (*Cordia cylindrostachya*), *Lantana camara* and *Hamelia* sp. All of these are favorite food plants of the beetle.

FLIGHT AND ATTRACTION TO LIGHT.

The flight of this species was observed in a rearing cage at Santa Rita on April 28, 1915. The first beetles took flight from the soil

at 7:06 P. M., the flight was at its height at 715, and ceased at about 7:26. The duration of flight was thus twenty minutes. Perhaps it would be somewhat lengthened under outdoor conditions, with no screening to confine the radius of flight.

No tests were made to determine the usual distance of flight, but it is probably limited largely by the proximity of agreeable food plants, as is the case with the larger species.

This species has the habit, common to all of the May-beetles, of flying to lighted lamps and electric lights in the early evening. At Santa Rita, where the experiments were conducted, it was less commonly taken at light than the larger species, even during its season of greatest abundance, from March to June.

Copulation.

Records of the time and duration of copulation were made on the same night as the flight observations. The time of joining and separating of three pairs was as follows: (1) started 7:17, ended 8:05, lasted 48 minutes; (2) started 7:22, ended 8:14, lasted 52 minutes; (3) started before 7:24, ended 8:12, lasted over 48 minutes.

From these it appears that copulation usually takes place, at this time of year, between the hours of 7:15 and 8:15, and has an average duration of about three-quarters of an hour.

Oviposition.

To determine the length of life of the adult, the length of egg-laying period and the average number of eggs laid by a female, sixteen pairs of adults of this species were confined separately in jars and fed regularly until their death. They were fed upon strips of banana leaf. Twelve pairs were confined on March 19, the other four pairs on April 6. The female of one pair died within three days, so that the records of only fifteen pairs are used in the calculations. The last female died on May 18.

From the fifteen females, the average length of life of the female adult was found to be 36 days. The longest life was 55 days, or somewhat under two months.

The average length of egg-laying period (the time included between the dates of laying of the first and last eggs) was 19.47 days; the maximum, 41 days; the minimum, 2 days.

The average number laid by a female was 15.6 eggs. The maximum number laid by one female was 40 eggs, which were laid in a period of 36 days, a rate of somewhat over 1 egg per day.

The average number of eggs laid per day, for the beetles' whole life, was .51; the average number per day for the egg-laying period only was 1.19 eggs.

The maximum rate of egg laying was 13 eggs laid in one day by one female. No other eggs were laid by the same female within 10 days before or after the date of laying the 13 eggs.

Comparing this species with *P. vandinei*, it will be seen that the average number of eggs per female, and the maximum length of egg-laying period, is about the same for the two.

The average length of life of a female, and the maximum number of eggs laid in 24 hours, is considerably less for this species than for *vandinei*.

On the other hand, the average number of eggs laid per day, and the average duration of the egg-laying period, is noticeably greater for this species than for *vandinei*. The average female of *guanicana* laid eggs at a rate of one every two days; the average female of *vandinei* laid at the rate of one every three days.

Insect and Fungus Enemies.

No insect parasites or predacious enemies are yet known to prey upon this May-beetle or its larva.

The stages of this insect that became infected by the green muscardine fungus in experimental boxes were as follows: Eight eggs, one grub of first instar, one grub of second instar, and nine (or probably more) adults. The hightest per cent of infection was among the adults; the next highest among the eggs. No grubs of the last instar were recorded as infected by the fungus.

THE CITRUS WHITE-GRUB.

Phyllophaga citri n. sp.*

This species receives its name from the fact that, although it feeds upon a large variety of plants, it is distinctly an inhabitant of the citrus orchards, and its larva is a pest that often gives much trouble to young citrus trees. The damage the grubs do to older trees is usually not known, and goes unheeded because of the greater ability of older trees to stand the reductien in feeding roots caused by the grubs. Young trees quickly show the damage of the root trimming done by the grubs. Inquiries that have been made of citrus growers

*This species has been mentioned as a supposed variety of *P. guanicana*, under the name of "*Lachnosterna* media (northern form)," in the Fourth Report of the Board of Commissioners of Agriculture of Porto Rico, page 48.

over much of the north and west sides of the Island as to the presence of this May-beetle in their orchards, and the damage done by it, have in many instances brought reply that the damage is considerable, and that little can be done to prevent it, except picking the beetles or grubs by hand or spraying with arsenate of lead. These are said to give only temporary relief.

While grubs of the two larger species, *vandinei* and *portoricensis*, may also be found to some extent at the roots of citrus trees, their occurrence is usually accidental. Adults of these species feed rarely if ever upon citrus foliage, and consequently do not often seek the soil at the bases of citrus trees to lay their eggs.

The citrus white-grub is also a pest of sugar-cane, of pasture grass, and of a variety of other crops. The grubs are sometimes found as abundantly as those of the larger species in cane fields that are being plowed. It is therefore quite as important a general crop pest, in some localities, as either the common or sugar-cane white-grub.

Distribution.

This seems to be the most widely distributed species of *Phyllophaga* occurring on the Island. Specimens have been collected at Mayagüez on the west coast, along the entire length of the north coast from Aguadilla to Fajardo, at Lares, Utuado, Aibonito, Cayey, and other towns inland, and on the south coast from Aguirre eastward. Specimens have also been collected on the Island of Vieques, to the east of Porto Rico.

The type of this species is from Río Piedras, in the San Juan district, which is midway (or a little east of midway) of the Island on the north coast. Specimens from other localities do not seem to vary much from the type, though it is possible that future study will reveal the presence of sub-species.

On Vieques Island, where sugar cane is the principal crop, this species is less abundant than *portoricensis*, and therefore less important as a pest.

The Beetle.

Superficially, this May-beetle very closely resembles *P. guanicana*. The average size is a little larger, about one millimeter more in length. As in that species, the elytra of the male are covered with a very fine, plumbeous pubescence, that makes it duller in color than the female. The latter differs from the female of *P. guanicana* in having the elytra, instead of uniformly polished over the surface, polished only on the disc back of the middle, while the sides and fore-part

of the elytra are plumbeous as in the male. This character may vary somewhat in individuals of any one locality, but is fairly constant for the species, from whatever locality.

The sure character by which to distinguish this species from *P. guanicana* is in the male genitalia, which has been figured in the preceding section of this paper. That part of the medium lobe of the male genitalia which has been called the spatha is depressed, chitinized and polished above, and unsymmetrical, being curved or hooked upward on the left side, where it terminates in a serrated edge.

The spatha of the male genitalia of *P. guanicana*, on the other hand, is thicker vertically than horizontally, is bilaterally symmetrical, and is fleshy except for two rows of minute, brown, prostrate spinules (directed forward) that form a V on the dorsal surface, and two similar rows, or edges, of spinules on the ventral surface.

Life-History.

Insufficient work has thus far been done on the life-history of this species to warrant saying more than that it is very similar to that of *P. guanicana*. It probably differs in no essential detail.

While the adults of this species appear in the earliest spring (in the last days of February) their occurrence seems to extend over a greater portion of the summer than does that of the other species, for specimens may be found even as late as October.

THE EGG.

In size and appearance, the egg does not differ from that of *P. guanicana*, which has been described. The average length of the egg stage, from a large number of observations, was ascertained to be 12.88 days, or practically 13 days, which is about the same as the egg stage of the other small *Phyllophaga*.

THE WHITE-GRUB, OR LARVAL STAGE.

The ascertained length of the first two instars of the grub was the same as for *P. guanicana*, and it may be expected that the last instar will also prove the same.

First Instar.—From three grubs carried through this instar, the average duration was 24 days, or exactly the same as the duration of that instar in *P. guanicana*. The only recorded measurement of a first instar grub was: length, 13 millimeters; breath of head, 1.45 millimeters.

Second Instar.—This was observed of but one grub, which required from 30 to 32 days between the first and second molts. The measurements of a single grub in this instar were: length, 22 millimeters; breadth of head, 2.65 millimeters.

Third Instar.—The duration of this instar has not yet been obtained. It is doubtless the same as that of *P. guanicana*. The average dimensions of four grubs in this instar were: length, 28 millimeters; breadth of head, 4.4 millimeters.

The Pupa.

The duration of pupal stage, from a single observation, was 23 days. The measurements of this pupa were: length, 20 millimeters; breadth at middle, 9.2 millimeters.

Food-Plants of Adult.

Some of the commoner trees and plants of the north side of the Island upon which this species feeds in common with the larger species (*vandinei* or *portoricensis*) are: flamboyant, casuarina, almendro, bucar (*Erythrina glauca*), quenepa (*Melicocca bijuga*), jobo (*Spondias lutea*), sombradera (*Albizzia lebbek*), muñeco (*Cordia borinquena*), and *Cordia corymbosa*. The list is not a complete one, but would include a large number of common forest and fruit trees, on which sufficient observations have not yet been made to know what species attack them.

A few trees and plants on which this species feeds abundantly to the exclusion of the two larger species are: grapefruit, orange, guava, silk oak (*Gravillea robusta*), *Acalypha wilkesiana*, garden rose, *Miconia racemosa*, *Clidemia hirta*, *Lantana camara*, *Triumphetta* spp., and *Urena lobata*. Further observations will lengthen the list.

Habits of Adults.

The attraction of the beetles to light, and the hours of flight and of copulation in the evening, are practically the same as for the adult of the Guánica white-grub. Flight has been observed up to 7:50 P. M., and copulation up to 8:15 P. M.

Studies are being made to ascertain the average length of the beetle's life, the duration of the period of oviposition, and the number of eggs laid by a female, but are not yet complete.

Insect and Fungus Enemies.

Subsequent to the segregation of the different species of *Phyllo*

phaga, no accurate observations have been made as to the parasites peculiar to each species; and the earlier notes of the Station do not in any instance indicate what species were the hosts of the parasites reared. It is possible, however, that both species of Tachinid fly, *Cryptomeigenia aurifacies* Walton and *Eutrixoides jonesii* Walton prey upon the adults of this species as well as upon those of the two larger species of *Phyllophaga*.

The predacious wireworm, *Pyrophorous luminosus* Illiger, is as truly an enemy of this white grub as of the two larger species.

The only stages of the species that have been found infected by the fungus are the egg, five of which were found covered with spores in June, in experimental jars, and the adult.

THE LITTLE BROWN MAY-BEETLE.

Phytalus insularis n. sp.*

This May beetle is so much smaller than the four preceding species as to be at once distinguishable from them, even to the layman. The type specimens of the species are from Santa Rita, in the Guánica district, collected by the writer. The species has also been collected at Añasco, Garrochales (near Arecibo), San Juan, Río Piedras and La Plata, so that its distribution is probably general over the western two-thirds of the Island. Whether it occurs at the eastern part of the Island is not known. More specimens by far have come from the Guánica district than from all other localities combined.

As both larvae and adults have been collected in the cane fields at Santa Rita, this species is considered among the cane pests. It is not, however, of much importance as a pest either to cane or to other crops, because of its scarcity. The mature grub being no larger than the sugar-cane white-grub is at the end of the first instar, it would require ten or more of them to equal in weight one mature grub of the larger species, and the damage committed by each must be correspondingly small.

Usually, among the grubs gathered in the plowed cane fields at Santa Rita by the grub pickers employed by Guánica Centrale, were to be found fewer than a dozen grubs of this May-beetle to each thousand of the sugar-cane white-grub. Often there were none; only certain fields contained grubs of this species. On the occasion when

* This species was first mentioned in the Third Report of the Board of Commissioners of Agriculture of Porto Rico (page 42), under the name of "*Lachnosterna* pequeña," and a summary of its lifecycle (except the pre-oviposition) given in the Fourth Report of the Board (page 47) under the same name.

the largest recorded number of these grubs was taken from a plowed cane field (tablón 21, hacienda Santa María, Feb. 25, 1915), actual count of a pailfull of grubs gave the following results: *Phytalus insularis* (all 3d instar), 38; *Phyllophaga vandinei* (2d and 3d instar), 970.

The Beetle.

The adult is dark, burnished brown with somewhat lighter margins, more noticeable on the thorax. The length varies from $9\frac{1}{2}$ to $11\frac{1}{2}$ millimeters, the breadth about half of that.

While not belonging to the genus *Phyllophaga*, this insect can very rightly be considered a May-beetle, because of its very close relationship to that genus in every particular. In fact, some of the characteristics upon which the genus is founded are so unstable as to cause some specialists to question whether the genus name should be retained. In the writer's opinion the genus is a valid one, because of the marked characters of genitalia, distinguishing it from *Phyllophaga*.

Life-History.

The life-cycle of this species, like the four preceding, covers just one year. In confinement, no grubs were successfully reared to maturity in the smaller boxes, but in a large outdoor cage a large number came through from egg to adult. The eggs from which these came were laid between August 25 and September 25, and the first adults of the new generation were observed in the cage on August 20 of the following year, clearly proving the life-cycle to be one year.

Unfortunately, the soil in this cage was not dug up and examined at the right time of year to find pupae, and preserve specimens of them. The pupa of this beetle is still unknown. On January 19, a part of the soil in the cage was examined, and 60 grubs were found, of which 57 were in the third instar and 3 at the end of the second instar. On April 30 all the soil was examined, and 134 grubs found, all of which were in the third instar, 2 of them dead and covered with *Metarrhizium* spores. No pupae were present at that date.

In the tin boxes, two grubs reached the pre-pupal stage, but both failed to pupate. From them, however, the length of the third instar was ascertained.

If we may estimate the pupal stage of this species as requiring 20 days, adding to this the averages for the other stages and instars, the average duration of egg-to-adult period is found to be 301 days (the same as for the sugar-cane white-grub); the maximum, 316 days; the minimum, 283 days.

THE EGG STAGE.

The average length of egg stage, calculated from the hatching of 146 eggs in confinement, was 11½ days, the maximum 12 days, the minimum 10½ days.

The dimensions of the egg are: when first laid—length, 1.5 mm.; breadth, 1 mm.; when much swollen and shortly before hatching—length, 1.9 mm.; breadth, 1.7 mm.

The eggs of this May-beetle are laid singly in the soil, in tiny pits, of about three times the diameter of the egg, and do not differ in any noticeable detail, except size, from the eggs of *Phyllophaga*.

THE WHITE GRUB, OR LARVAL STAGE.

The larval stage requires, from our figures, an average duration of 268½ days (or about 9 months). The maximum duration, obtained by adding together the maximum lengths of the three instars, was 284 days; the minimum, 252½ days.

No larvae younger than the third instar are found in the fields after the latter part of January; no larvae of the first instar are found after November.

First Instar.—The average duration of this instar, from 30 grubs, was found to be 30 days; the maximum, 39½ days, the minimum, 21½ days. The measurements of the grub in this instar were not obtained, but can be easily estimated from the size of the egg.

Second Instar.—The average length, from records of 10 grubs, was 45¼ days; the maximum, 54 days; the minimum, 37 days. The dimensions of the only second-instar grub measured were: length, 10 millimeters; width of head, 1.5 millimeters.

Third Instar.—The length of the last instar, averaged from but two grubs, was 194 days. One of these required 186½ days and the other 197 days to reach the pupal stage.

Of twenty grubs in this instar that were measured, varying from 16 to 22 millimeters in length, the average width of head was 2.63 millimeters.

PUPA AND PRE-EMERGENCE OF ADULT.

The length of the pupal stage has not been determined, but doubtless requires in the close neighborhood of 20 days.

Pre-emergence in the Guánica district at least, where the adults first appear in the fields in August, probably requires a shorter time than in those species which issue during the cool winter months, and wait until spring to emerge from the soil.

SEASONAL DISTRIBUTION.

The season of appearance of the adults seems to vary considerably in different localities. All adults that have been collected at Santa Rita were found between early August and the middle of October. A specimen was collected at Añasco in September.

A number of specimens from La Plata, in the center of the Island, were colilected in the middle of June.

At Garrochales, near Arecibo, the writer collected 35 specimens, on one Lantana plant by the road, on April 26.

Single individuals collected by electric light at San Juan and Río Piedras bear the following dates: June 6, July 4, August 25, October 15, November 8 and December 1, thus covering a range of seven months.

FOOD PLANTS OF ADULTS.

At Santa Rita, all specimens collected by the writer were found feeding upon "bledo," or pig weed (*Amaranthus* spp.), or upon "malojillo," or Para grass (*Panicum barbinode*), the majority upon the former. A single specimen was feeding upon "saleilla" (*Schrankia portoricensis*). In experimental cages adults were seen feeding upon corn foliage. No specimens were seen feeding upon cane, though they occurred plentifully in the cane fields, and doubtless the grubs attacked cane roots.

The series of beetles collected at Garrochales were all feeding upon *Lantana involucrata*, though there was a great variety of other vegetables near at hand.

FLIGHT AND ATTRACTION TO LIGHT.

Flight of the species was observed at Santa Rita in a large rearing cage on the night of September 1, 1914. The first individuals left the ground and took wing at exactly 6:55 P. M. The numbers in flight increased most rapidly from 6:55 to 7:00, and continued heavy until nearly 7:10, then gradually dropped off. By 7:20 flight was quite light, but continued to some extent until 7:30, when a very few were still flying. The last beetle ceased flying about 7:35. Most of the beetles flew against the west side of the cage.

All the specimens of this beetle collected at Río Piedras or San Juan have been taken at light, and a very few were taken at Santa Rita at a large gasoline lamp.

Copulation and Oviposition.

On September 1 these observations were made:

Pairs began mating at 6:57 P. M. At 7:05 over a dozen pairs were mating. At 7:07 pairs were beginning to separate. At 7:15 the majority had separated. At 7:25 the last pair separated.

And on the following evening, similar observations: First pair united at 6:57: largest number copulating. 7:05: last pair separated. 7:28. Total time consumed. 31 minutes.

Exact records of six copulating pairs on the same night were as follows:

(1) United. 6:58; separated. 7:06; time spent. 8 minutes.
(2) United. 6:59; separated. 7:08; time spent. 9 minutes.
(3) United. 7:01; separated. 7:10; time spent. 9 minutes.
(4) United. 7:02; separated. 7:12; time spent. 10 minutes.
(5) United, 7:01; separated. 7:11; time spent, 10 minutes.
(6) United. 7:08; separated. 7:23; time spent. 15 minutes.
Average length of time spent in copulation, 10 minutes.

Those pairs on or near the ground copulated without taking flight. In no case was a beetle seen to take flight after copulation. As with the species of *Phyllophaga*, they immediately begin to feed after copulation: and if resting on a leaf, the female usually feeds during copulation, the male never. About 50 per cent of the beetles copulated without first taking flight.

The females, in the receptive mood, rest with the abdomen slightly raised, and with the genitalia protruded in a conspicuous florescence, which is pale yellow in color and fully three times as great in diameter at the tip as at base. In this position they rest for ten minutes or longer until a male appears.

No females of this species were confined singly to secure eggs. Females were, however, confined in numbers at different times in jars with food to secure eggs. The average rate of egg laying computed from the eggs thus secured was one egg in three days by each female. At which rate, a female living two months would lay only twenty eggs. This figure may not be accurate since, in confining numbers of beetles together, some eggs are necessarily destroyed by the beetles in boring into the soil.

Insect and Fungus Parasites.

No insect parasites have yet been discovered preying upon either larva or adult of this May-beetle.

The only stages of this May-beetle that became infected by the

green fungus were the adults, and grubs of the last instar. No record was kept of the number of adults, but it exceeded a dozen. Of the grubs reared, a rather astonishingly large number became infected, in the jars and boxes, by this disease. Out of 142 third-instar grubs kept in confinement under observation, there is record of 13 becoming infected by this fungus, which is 9 per cent of the total number, a higher per cent than was noted of the grub of any other May-beetle except *Phyllophaga vandinei*.

Summary of Life-cycles and Measurements of May-Beetles and White-Grubs.

THE SUGAR-CANE WHITE-GRUB, *Phylloghaga vandinei* N. SP.

	Maximum	Minimum	Average	Number	Long	Wide	Head
Egg Stage.........	16	10	14	1.089	2.97	1.7	....
Grub, 1st Instar...	59	17	36½	184	6-17	....	1.94
" 2d " ...	103	26	47	71	16-28	....	3.32
" 3d " ...	226	78	183	25	27-45	....	5.31
Pupal Stage. .	26	17	21½	22	23-27	10-12	....
Total.........	430	148	302	1,391	....	....	....

THE COMMON WHITE-GRUB, *Phyllophaga portoricensis* N. SP.

	Maximum	Minimum	Average	Number	Long	Wide	Head
Egg Stage.........	15	12	13½	51	3.0	1.75	....
Grub, 1st Instar...	40	26	32	6	6-18	....	2.10
" 2d " ...	93	43	61	6	18-30	....	3.45
" 3d " ...	171	164	169	2	30-48	....	5.70
Pupal Stage.	23	20	21½	5	25-29	11-13½	....
Total..........	315	265	297	73	....	....	....

THE SOUTH COAST WHITE-GRUB, *Phyllophaga guanicana* N. SP.

	Maximum	Minimum	Average	Number	Long	Wide	Head
Egg Stage.........	19	11	13½	505	2.05	1.2	....
Grub, 1st Instar...	35	13	21	60	4½-12	....	1.33
" 2d " ...	39	23	31	38	12-20	....	2.38
" 3d " ...	221	138	178	6	20-32	....	4.10
Pupal Stage.......	(22)	(22)	22	1	18	7.9	....
Total..........	336	207	268½	610	....	....	....

THE CITRUS WHITE-GRUB, *Phyllophaga citri* N. SP.

	Maximum	Minimum	Average	Number	Long	Wide	Head
Egg Stage.........	....	....	13	200	2.12	1.25	....
Grub, 1st Instar...	....	....	24	3	5-13	....	1.45
" 2d " ...	....	....	31	1	13-22	....	2.6
" 3d " ...	....	....	(178)	0	22-31	....	1.1
Pupal Stage.......	....	....	23	1	20	9.2	....
Total..........	....	....	269	205	....	....	....

	Maximum	Minimum	Average	Number	Long	Wide	Head
Egg Stage.........	12	10½	11½	146	1.45	.90	....
Grub. 1st Instar...	39½	21½	30	30	3½-8	....	....
" 2d " ...	54	37	15¼	10	8-14	....	1.5
" 3d " ...	197	191½	194¼	2	14-22	....	2.63
Pupal Stage.......	(20)	(20)	(20)	0	12¼	5.1	....
Total..........	322½	280½	301	188	....	....	....

* The columns of figures in the above table (which were all obtained by actual observation or actual measurement), numbered from left to right, may be explained as follows:

(1) Maximum duration in days of the immature stages, the totals being the maximum egg-to-adult period for each species, in days.

(2) Minimum duration in days of immature stages, etc.

(3) Average duration in days of immature stages, etc.

(4) Numbers of eggs, grubs, or pupae, averaged to obtain the figures of the first three columns.

(5) Average length in millimeters of each of the immature stages, taken from a number of measurements made with sliding calipers.

(6) Average breadth in millimeters of egg and pupa of the various species, from measurements with sliding calipers.

(7) Average breadth in millimeters of the head of grub in each instar of the five species, from measurements with sliding calipers.

THE EGGPLANT LACE-BUG IN PORTO RICO.

Corythaica monacha Stal.

By R. T. COTTON, Assistant Entomologist, Insular Experiment Station.

The growing of the eggplant *Solanum melongena*, is made difficult by the ravages of a great many insect pests, the worst of which is undoubtedly the lace-bug *Corythaica monacha* Stal. This bug is widespread over the Island and attacks the eggplant wherever it is grown, causing heavy damage when not controlled by spraying. It feeds normally on the so called wild eggplant, *Solanum torvum*, and it is on this plant that it is able to survive during the intervals between crops. *Solanum torvum* is one of the most abundant of weeds on the Island, growing luxuriantly in all parts and at all times, and it is undoubtedly owing to this fact that the lace-bug is so abundant. If it were dependent solely on the cultivated eggplant for its food supply it would soon die out, but as the eggplant is seldom grown at all times of the year even in the most favorable localities.

The injury to the plant is occasioned by the feeding of the nymphs and adults, which congregating in hundreds on the undersides of the leaves, suck the vital juices from the plant. Their presence on the leaves is first indicated by the appearance of small yellowish-brown patches, which growing in size soon involve the entire leaf causing it to dry up and fall off. It is not an uncommon sight to see a whole patch of eggplant entirely denuded of its leaves. The insect has a very short life cycle and multiplies so rapidly that once introduced into a field it soon spreads to every plant.

LIFE-HISTORY.

This insect breeds continously through the year. The mature female lays a large number of small, flask-shaped eggs, which she inserts into the tissue of the leaves, until only a little more than the crater-like tops protrude through the epidermis. The eggs are placed singly on the undersurfaces of the leaves and are scattered over the entire area. The length of the egg stage varies from five to seven days with the majority hatching in six days. The following table is an extract from breeding notes taken at various times of the year:

Table 1.—Length of Egg-Stage of Lace-Bug.

No.	Eggs laid	Eggs hatched	Incub. period	No.	Eggs laid	Eggs hatched	Incub. period
			Days				Days
1	July 5.......	July 11.......	6	7	Dec. 2.......	Dec. 8.......	6
2	July 10.......	July 15.......	5	8	Dec. 4	Dec. 11.......	7
3	July 20.......	July 26.......	6	9	Dec. 10.......	Dec. 16	6
4	Aug. 4.......	Aug. 10.......	6	10	Jan. 3.......	Jan. 9.......	6
5	Aug. 16.......	Aug. 22.......	6	11	Jan. 7.......	Jan. 14.......	7
6	Sept 2.......	Sept. 7..... ..	5	12	Jan. 8.......	Jan. 14.... ..	6

The young nymphs are quite active at first but soon settle down to a quiet existence, feeding together in large colonies on the undersides of the leaves. Occasionally a few may be seen feeding on the upper surface of the leaves and when feeding on the weed *Solanum torvum* they feed as much on the upper as on the lower surface of the leaves. The nymphs develop quite rapidly, passing through five successive moults before attaining adult form. The period between moults is remarkably constant being in practically all cases of two days duration. The following table is a record of the moulting periods of some of the individuals reared in the laboratory:

Table 2.—The Moulting Stage of Nymphs of Lace-Bug.

No.	Date hatched	First moult	Second moult	Third moult	Fourth moult	Fifth moult	Adult
1	July 23	July 25.....	July 27.....	July 28.....	July 30.....	Aug. 1..............	
2	July 23.....	July 25.....	July 28.....	July 30.....	Aug. 1.....	Aug. 3..............	
3	July 23.....	July 25.....	July 27.....	July 29.....	July 31	Aug. 2..............	
4	Aug. 2......	Aug. 4......	Aug. 6......	Aug. 8.....	Aug. 9.....	Aug. 11..............	
5	Aug. 2......	Aug. 4	Aug. 5......	Aug. 7.....	Aug. 9.....	Aug. 11..............	
6	Aug. 5......	Aug. 7......	Aug. 9......	Aug. 11.....	Aug. 13.....	Aug. 15..............	
7	Oct. 1.......	Oct. 5.......	Oct. 7.......	Oct. 9......	Oct. 11......	Oct. 13..............	
8	Oct. 4.......	Oct. 6.	Oct. 8.......	Oct. 10......	Oct. 12......	Oct. 14..............	

The time taken from the hatching of the nymph to the appearance of the adult is thus only ten days, an extremely short time, and as the females are quite prolific in their egglaying, the increase in numbers of the insect is very rapid.

Description of Stages.

The Egg.—Length .48 mm., width .22 mm., flask-shaped with the neck bent to one side. Top of egg crater-like, having a ragged border and a circular impressed area that is cross-hatched with delicate markings. This circular top is .13 mm. in diameter and acts as a lid that is pushed aside when the young nymph hatches. Egg white in color, translucent; surface smooth and shiny.

First Stage.—Length .65 mm., width .36 mm.: body slender, general color pale yellowish dorsally, fading to white on the ventral surface. Eyes red, antennae short, and club-like at the tip.

Second Stage.—Length 1.09 mm., width .52 mm.; body oblong-ovate, general color a pale yellowish white; margins of abdomen and thorax and dorsal surface of head, thorax and abdomen armed with spiny tubercules, tubercules on dorsal surface dusky; tips of antennae and tarsi a light brown.

Third Stage.—Length 1.53 mm., width .8 mm.; similar in form to previous stage only larger, and has rudimentary wingpads; dorsal spines darker in color and regions round them dusky, forming a distinct color pattern.

Fourth Stage.—Length 1.75 mm., width 1 mm.; similar in form to previous stage only larger, body markings darker; wingpads much longer, their tips dusky-brown.

Fifth Stage.—Length 2.3 mm., width 1.2 mm.; body oblong-ovate, dorsal surface more or less flattened; general color a yellowish-grey, with a few dark brown markings. Last six segments of the abdomen provided on each side with a marginal tubercule armed with one long and several shorter spines, the abdomen apparently terminating in two of these spiny processes; first two pairs of marginal abdominal tubercules a dusky-brown. The *metanotum* provided with two large, dark-colored tubercules armed with spines, the abdomen provided with three median, dorsal tubercules similar to those on the *metanotum*; wingpads each armed with a marginal tubercule and several marginal spines. Head armed with three tubercules and two anterior marginal spines; head light in color except posterior margin which is dusky; pronotum light in color with two dusky bars near the anterior end arranged in the form of a V. *Metanotum* dark, abdomen light in color with dusky segmentation marks and dark-colored tubercules. Wingpads light colored with a dark spot on the disk, and with dusky tips. Antennae about one-third the length of body, clothed with a few short hairs, the tip somewhat club-shaped and dusky-brown in color. Legs fairly long and slender, terminating in chitinized claws, general color light except tarsi which are dark brown.

Adult.—This lace-bug is a delicate lace-like little insect belonging to the heteropterous family *Tingitidae*. It is one of the very few representatives of this interesting family that inhabit the Island of Porto Rico. It is about 3.5 mm. long, body dark, hood and lace-like wings grey marked with brown.

NATURAL ENEMIES.

Several predaceous insects feed on the soft-bodied nymphs of this lace-bug, among which are the Coccinelid beetles *Megilla innonata* Vauls. and *Cycloneda sanguinea* Linn., and the *Reduviid* bugs *Zelus rubidus* Lap. and Serv. and *Z. longpipes* Linn.

CONTROL.

This insect may be effectively controlled by a soap-and-water spray, eight pounds of soap to fifty gallons of water being a good strength to use. The plants should be sprayed as soon after the appearance of the lace-bugs as possible, since it is much easier to control them then than later.

LIFE HISTORY OF HALTICA JAMAICENSIS FABR.

By R. T. COTTON, Assistant Entomologist, Insular Experiment Station.

In 1792 Fabricius described this beetle under the name of *Galleruca jamaicensis*, but a year later becoming uncertain of his species he changed the name to *G. bassiae*. In 1808 Olivier gave the name of *G. plebja* to this species, and Sturn in 1843 gave it the name of *Graptodera tarsata*. In 1875 Harold recognized *jamaicensis* as the correct name calling it *Haltica jamaicensis* Fab. and relegating the other names to synonymy.

It is recorded as occuring in Jamaica, Santo Domingo, Haiti, Porto Rico, Costa Rica, and Cuba. It apparently varies quite a little in color in different localities, but there is doubtless but one species concerned.

This beetle is the largest of the flea-beetles found in Porto Rico and at times is extremely abundant. Confining its attention chiefly to one of the common weeds, *Jussiaea leptocarpa* and two closely allied plants *J. suffruticosa* and *J. erecta*, it occasionally feeds on garden beans and conceivably might do great damage if for any reason its ordinary food supply should give out.

Both adult and larva feed very voraciously on the foliage of the *Jussiaea* plants, usually entirely stripping the plants in their immediate vicinity.

LIFE HISTORY.

The eggs are laid in batches of from one to thirty, sometimes side by side in a regular row, sometimes massed together one on top of the other. They are a pale buff yellow color, oblong-oval in shape

and are placed on the leaves and stems of the plant. Although sometimes concealed in folds of the buds and flower-heads they are more often in plain view, placed on the upper surface of the leaves. The adult females are very productive, one female in captivity producing eight hundred and eighty-seven eggs during a period of sixty-eight days. The average, taken from the laying record of thirty females, was five hundred and twenty eggs.

The eggs hatch in from four to six days, and the young larvae that emerge begin at once to feed upon the foliage. Growing rapidly the larva moults at the end of five days and again three days later. Growth continues rapidly for a few days, then becomes slower and slower until no further increase in size is perceptible, yet it is not until fifteen days later after the second moult that the larva descends to the soil to pupate. Five days are spent in a prepupal state and six more in the true pupal state before the adult beetle actually emerges, thus making a total of thirty-nine days from egg to adult.

Technical Description of Stages.

Adult.—A large steely blue beetle. Original description by Fabricious.

Oblonga cyanea antennis pedibusque nigris affinis C. alni at alia et minor, thorax et elytra cyanea, nitida, immaculata, abdomen obscurum. Pedis niger.

Egg.—The egg is pale yellow in color, oblong-oval in shape, and provided with an exterior covering that is usually broken in places, showing the inner shell. This exterior covering is finally reticulated and dull in appearance. The inner covering is slightly shining and is sculptured with hexagonal-shaped markings. Length 1.2–1.3 mm. Width .45–.5 mm.

Larva.—Robust, tapering gradually from the fourth abdominal segment both cepheled and caudad; general color yellowish-brown, with numerous black tubercules on each segment; head black, thoracic and anal plates black and strongly chitinized; legs black, head and body well supplied with numerous spine-like hairs. Length 14 mm., greatest width 3 mm.

The immature stages of the larva are smaller, and the tubercules closer together, giving the first-stage larva the appearance of being almost black.

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SCALE-FEEDING HABITS OF A PORTO RICAN MILIPEDE.

Rhinocricus arboreus (Saussure).

By R. T. Cotton, Assistant Entomologist, Insular Experiment Station.

While investigating the feeding-habits of some of the common millipedes of the Island, to ascertain whether or not they were injurious to truck crops, I was surprised to find that one of the species had the very interesting habit of feeding on the purple scale of citrus, *Lepidosaphes beckii*.

This millipede is a large, dark reddish-brown form about 80 mm. long. Dr. R. V. Chamberlin of the Museum of Comparative Zoology, Cambridge, Mass., has very kindly identified it for me as *Rhinocricus arboreus* (*Saussure*) and says that it is known from several other West Indian Islands, St. Thomas, St. Croix, Antigua, etc.

It was while walking through a citrus grove at Río Piedras, P. R., that my attention was attracted by seeing several specimens of this millipede, among the branches of the grape-fruit tree that was heavily infested with the purple scale. Pausing to watch them for a few minutes, I noticed that they were feeding voraciously on the scale, and smooth, clean patches on the scale-infested branches indicated where they had been at work. Transferring them to the laboratory I placed them on grape-fruit twigs that were completely covered with

scales, and in a very short time the twigs were cleaned off. Some idea of the voracity of this millipede may be gained from the fact that one specimen, by actual count, consumed two thousand scales in a period of three hours, and after a short rest continued feeding.

This species of millipede is quite abundant in this locality, and in order to satisfy my curiosity as to whether or not I could entirely clear a tree of scales by them, I captured a number of them and placed about a dozen, in each of several small grape-fruit trees that were badly infested with the purple scale. They seemed perfectly contended with their new surroundings and commenced at once to feed on the scales. At the end of two weeks the trees were perfectly clean and free from scales and the bark took on a fresh green color. At this time most of the millipedes left the trees in search of more food although one or two remained and are still in the trees, four or five months after they were introduced. Singularly enough these trees are still perfectly clean although they have had no other treatment, while other trees in the block that were sprayed with an oil emulsion, but did not have any millipedes, are again very heavily infested with scale. Although they are never likely to be of any great importance in controlling scale insects in the grove, it is interesting to note this habit of a supposedly vegetable feeding myriapod.

Although preferring the purple scale, this millipede will feed on other scales, as I have found by experiment with specimens in the laboratory. I have not observed them in the field feeding on any but the purple scale. I do not wish to leave the impression from these notes that the millipede in question feeds entirely on scales, because it does not, the scales being but a part of its diet.

In dissecting out the alimentary canals of some specimens of this millipede, I was interested to find that they were all very heavily infested with worms, which according to Dr. B. H. Ransom, "represent four different species of nematodes, none of which appear to have been described. The largest and most numerous form agree very well with the genus *Isakis* Lespés, 1856, the type species of which occurs in termites." The other three species have not as yet been placed generically.

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SUGAR-CANE FUNGI AND DISEASES OF PORTO RICO.[1]

By JOHN R. JOHNSTON, formerly Pathologist and JOHN A. STEVENSON, Pathologist Insular Experiment Station.

INTRODUCTION.

THE NEED FOR INVESTIGATIONS OF CANE FUNGI.

The sugar cane (*Saccharum officinarum*) as an economic crop has been grown in Porto Rico since at least 1548, when the first mill was erected and during all this period has doubtless suffered from the various common diseases, although no published reports are available until about 1870–80. During this latter period there occurred a most serious epidemic in the western section of the Island, occasioning heavy loss. From that time on, although the epidemic as such passed, there was continued loss through cane diseases, combatted as information given by planters indicates, by change of land and the introduction of new varieties. Following the American occupation, which gave a great impetus to the industry, the greatly increased areas given over to cane have meant increased losses from fungus attacks, more especially where the extra care in cultivation, so necessary when one crop is grown continuously, has not been given.

In some years it has been common to find whole fields ruined by one or another disease: and in certain areas it is impossible to grow more than one or two crops of cane without a period of rest in contrast to many parts of Cuba and Santo Domingo where an indefinite number of ratoon crops are obtained without replanting.

[1] This paper was originally prepared by Mr. Johnston previous to his resignation in September, 1914, as pathologist of the Insular Experiment Station and was at that time nearly complete, including drawings and photographs. Circumstances not having permitted of its publication before the present date it has now been completely revised and rewritten to permit of the inclusion of all data obtained in the past three years by the junior author, who has carried on the work since Mr. Johnston's departure as well as having been connected with the project for a year previous to that time as assistant pathologist. A considerable number of additional species, some of them new, have been added, and others orginally only provisionally named have been determined and inserted, together with many supplementary notes and observations on the other species. The drawings are the work of the senior author, the photographs were for the most part originally prepared jointly, and the present selections and arrangements have been by the junior author, including some new additions.

Acknowledgment is made for assistance in the matter of determinations to Mrs. F. W. Patterson, U. S. Department of Agriculture; Dr. E. A. Burt, Missouri Botanical Garden; Dr. F. J. Seaver, and Dr. W. A. Murrill, New York Botanical Garden; Prof. C. G. Lloyd; and Dr. W. C. Sturgis. Further acknowledgment is made in connection with the description of each species on which help has been had.

The junior author assumes responsibility for the form in which the paper is here presented as well as for any errors that may occur.

In some cases it is impossible to grow any cane whatever on what apears to be fairly good soil. Furthermore, in many fields of healthy looking cane it is not uncommon to find an enormous number of stalks completely rotted.

In the course of the field work carried on by this department, numerous cases of loss (totalling many acres) from root disease, rind disease and other causes have been investigated. To the losses from the all-sufficient array of common diseases heretofore known, is now added the epidemic in the northwestern quarter of the Island, where the monetary loss has already reached a total of some hundreds of thousands of dollars. It should by no means be considered that diseased cane is more abundant than healthy, but rather that it is often found very abundant over large areas, and far more prevalent than should be the case.

Although sugar cane diseases have been studied for many years, yet even today there is considerable contradiction to be found in the literature on the subject as to the cause of certain diseases and as to their relative importance. This lack of unanimity of opinion is partly due to inaccurate, or to incomplete work on the part of some of the investigators, but is also due in part to the fact that certain fungi causing disease vary in their behavior in different localities, in different countries, and in different varieties of cane.

For these reasons the work of sugar cane pathologists in other countries may be taken as only suggestive as to the probable conditions in Porto Rico, and the local problems must be worked out here on the Island itself. In addition to working over parasitic fungi that have been studied by others, there are also constantly arising new problems more or less peculiar to this country.

The following report is intended to be a complete discussion of the cane fungi of Porto Rico, so far as they have been determined and so far as definite knowledge has been obtained regarding them. The report includes not only popular descriptions of the fungi, and the diseases which they cause, but tecvhnical descriptions of the important forms as well, since it is desired that the planters may be informed of the various destructive fungi present in their cane fields, and at the same time it is important that other workers in the subject may be in a position to know what fungi occur, together with the symptoms of the resulting diseases.

It is perhaps needless to say that there is still much to be learned about the cane fungi of Porto Rico, especially as regards problems of control, but nevertheless it seems eminently desirable at the present time to issue in one report such data as is available, inasmuch as

all the hitherto published data occurs as scattered notes in various publications, and many notes are here published for the first time.

The identification of the fungi mentioned in this paper has been accomplished with considerable difficulty, owing to the lack of the necessary literature and authentic specimens for comparison. The material, however, has been worked over and over for a period of nearly seven years, and it is believed that the specimens here reported actually represent the various species as designated and at least as they are commonly accepted. With regard to the new species named by the authors, such action has been taken to facilitate reference to forms of common occurrence which it has not been possible to connect with previously established names, although it is freely recognized that our scanty resources in the way of mycological literature may have resulted in some errors. It is held, however, that it is preferable to give a complete name to such fungi together with a description and illustration, than to merely refer them to their genera or leave them out entirely.

Between twenty and thirty other fungi, many of them of the family *Agaricaceae*, have been collected but are in large part omitted from the present paper, because of insufficient material for study. None are of any known economic importance, and for the most part have been collected but once. A list of these is given in so far as it has been possible to place them in the proper genera.

PREVIOUS WORK IN PORTO RICO.

In as much as the present paper is based upon investigations carried on since November, 1910, and as there have been no studies along this line in Porto Rico since that time, other than those of the authors' or than those carried out in cooperation with them, it will include the whole history of the study of cane fungi and diseases, if a short resumé of work prior to the above date is given, together with an account of the various publications issued from this Experiment Station since that time.

It has been difficult to obtain information either oral or published concerning the epidemic of 1872–80, although it is known to have been most severe. It was investigated by a commission of three members, including Dr. Agustín Stahl and a report issued in 1878 (1[1]). In spite of their earnest endeavors no cause was found and their principal recommendation was the introduction and cultivation of new and more resistent varieties.

[1] Figures in parenthesis refer to literature cited, page 238.

Some years later Don Manuel Fernández Umpierre (89) published an account of his observations and experiments for the control of the situation in his *Manual Práctico de la Agricultura de la Caña.* According to his statements the disease, if such it were, was completely controlled by thorough preparation of the soil, and subsequent careful cultivation with especial care to provide proper ditching. This latter detail was considered of great importance for the providing of a uniform moisture supply, avoiding the extremes of a water logged soil or a parched condition due to excessive drainage and evaporation in times of drought.

According to Massee (61) a cane fungus was sent from Porto Rico in 1878 to M. J. Berkely, who named the species in a letter *Darluca melaspora.* Cooke in publishing this species ascribes the fungus to Australia, which is considered an error by Massee. The identity of the fungus, whether with *Diplodia* or with *Melanconium sacchari,* is not positive but with little doubt pertains to *Melanconium,* although both fungi occur here.

With these exceptions there appear no available notes on the cane fungi up to the time of investigations by the staff of the Mayagüez Experiment Station. In 1903 Prof. F. S. Earle (21) of the New York Botanical Garden made a brief investigation of the insects and the diseases of the economic plants of Porto Rico in the course of which he encountered a sugar-cane root rot. He describes this disease (found between Yauco and Ponce) as one in which the young ratoon canes were very pale in color, almost milk white, and their growth very feeble. The old stubble and the base of the young cane was enveloped in a mass of white mycelium of some hymenomycetous fungus. No fruiting bodies were found on the stubble or young cane but specimens of a *Schizophyllum* were found and the suggestion is made that there may be some connection between the fungus and the diseased condition. On succeeding pages it will, however, be noted that what was seen by Prof. Earle was undoubtedly a case of chlorosis of cane together with one of the root fungi, presumably *Marasmius sacchari* or the stellate-crystal fungus, *Himantia stellifera.*

In the report of the Mayagüez Experiment Station for 1907 W. V. Tower (86) reported an outbreak of the rind disease (due to *Melanconium sacchari*) on the south side of the Island.

In the report for 1908 G. L. Fawcett (26) reported the sugar cane of Porto Rico as largely free from fungus diseases, with the exception of some districts on the east coast where there had been excessive rainfall. The canes in one field were found to be suffering much

from the attack of a soil fungus which was not identified. Slight attacks of the root disease were noticeable in many comparatively healthy fields in other parts of the Island. The rind disease was also present to some extent in some of the fields.

In the report for 1909, Fawcett reported "that root disease of cane caused by the attacks of various organisms is quite prevalent, especially on poorly drained fields of old ratooned cane. Two of the fungi reported as prominent in causing this disease, (*Marasmius sacchari* and the stellate-crystal fungus have been found. Up to this time the latter fungus has been noticed only on old leaf-sheaths, never on freshly decayed roots. * * * The rind disease is common but as it is invariably found following the attacks of stalk-borers and does not affect plants except those already spoiled by these insects, it is hardly to be considered. For the pineapple disease which destroys the new planted seed cuttings, dipping of the seed cane in Bordeaux mixture is practiced on some of the large plantations with results reported as successful."

A bulletin (63) of the Mayagüez Station published in 1910 devotes a page to a general discussion of diseases of the sugar cane, stating that the root and pineapple diseases occur in Porto Rico, and referring the former to *Marasmius plicatus*, an error.

During the same year Mr. John R. Bovell, Superintendent of the Local Department of Agriculture of Barbados visited Porto Rico at the invitation of Guánica Centrale, confining his studies to the fields of that company. In his report (9) he lists the following diseases found attacking the cane:

Root disease	*Marasmius sacchari* Wakker.
Stem (red-rot) disease	*Colletotrichum falcatum* Went.
Pineapple disease	*Thielaviopsis paradoxa* (De Seynes) v. Hohn.
Rind disease	*Melanconium sacchari* Mass.
Ring spot	*Leptosphaeria sacchari* v. B. de H.

A general discussion follows of the value of producing new seedling varieties, of the necessity of cleaning badly diseased fields of all infected material (the burning of trash is recommended), of the proper methods of cultivating, and of treating seed. The use of legumes, in particular of cowpeas, is recommended as well as the making of silage of cane tops. The report concludes with notes on the prevalence and symptoms of each of the diseases listed.

Work on the diseases of sugar cane was taken up at the Experiment Station of the Sugar Producers' Association of Porto Rico in November, 1910, as already noted, and the first report (45) of progress was published in the following year. This included a general

discussion of the subject of cane diseases and their treatment, followed by specific accounts of the more important diseases encountered, their symptoms, causes, and methods of control. Eleven diseases are so treated, root disease, rind disease, red rot, red spot of the leaf-sheath, red rot of the leaf-sheath, dry rot of the stalk, leaf spot, top rot, and chlorosis.

In the report of the next year (46) progress is reported in the field and laboratory studies of various fungi, and the results of preliminary experiments for the control of the various diseases are given.

The senior author presented before the December, 1912, meeting of the American Phytopathological Society a paper entitled "Notes on the Fungus Diseases of Cane in Porto Rico," an abstract of which appeared in "Phytopathology" (47). This paper listed some twenty-three species of cane fungi, not all of them completely determined, and gave some notes concerning their economic importance.

The third report (50) of the pathologist contained a list of projects then under way, including studies of root diseases, red-stripe disease, and field experiments for control of some of the other cane maladies. Two further publications (48, 51) issued at about this time deal in general with cane diseases and their control.

In the third report of the Board of Commissioners of Agriculture, issued at the time when the Sugar Experiment Station had been but lately turned over to their direction as the Insular Experiment Station, occurs a statement of projects, some of which concern sugar-cane fungi and diseases. Additional notes on the subject have been included in the fourth and fifth reports (74, 75) of the Board issued since that date, further mention of which will be made in the specific accounts to follow.

DISEASES NOT OCCURRING IN PORTO RICO.

While Porto Rico has its full measure of cane diseases, it is, however, fortunate, to the extent that quite a number of diseases serious in other parts of the world do not occur here. Foremost among these may be mentioned Sereh, the mysterious malady of Java and the East Indies. In some respects the mottling disease, or whatever term may be given the present epidemic, resembles Sereh without the distinguishing symptoms of the latter being present. It has in its progress to date, however, resulted quite as seriously as any Sereh attack could.

The gumming disease due to the action of a bacterium (*Bacterium vascularum* Er. Sm.) and present in New South Wales, Hawaii, and other parts of the world, is a serious cane disease not encountered

here. The iliau (*Gnomonia iliau* Lyon) of Hawaii and Louisiana is still another disease that has not reached the Island. Among minor maladies are the rust (*Uromyces Kuhnii* [Krüger] Wak. & Went), the smut (*Ustilago sacchari* Rabenhorst), an internal rot due to *Cephalosporium sacchari* Butl., black rot (*Sphaeronema adiposum* Butl.), and a number of leaf spots. No phanerogamic parasites have been collected.

A plant quarantine service was established in 1910 and cane cuttings brought to the Island since that time have been carefully inspected and treated. Many importations have been destroyed or planted in quarantine for observation. Through the continuance of this service it is hoped that Porto Rico will be spared the necessity of combating any new additions to the already long list of sugar-cane maladies.

DISEASES ATTACKING THE ROOTS AND BASE OF THE STALK.

THE ROOT FUNGUS (*Marasmius sacchari*).

Marasmius sacchari has been collected from practically all parts of Porto Rico, some of the determinations being based only upon the vegetative condition, but for the most part upon the fruiting bodies so that the determinations are to be relied upon. The sporophores are found commonly only in the rainy season when the ground and surface layer of vegetable matter are completely soaked. They occur both upon cane trash and upon the lower leaf sheaths of the standing cane.

This fungus occurs commonly only on fairly heavy or heavy soils, seldom on sandy soils. It is most abundant in low lands that are too heavy to plow with any convenience, or in land that has not been well plowed through neglect or other reason. It is found most abundantly in fields of ratoon cane, and the poorer the soil and the cultivation given, the greater is the damage from this fungus. Fields affected with chlorosis were examined to see if such a condition favored the development of the root fungus. In no case did there seem to be any correlation between chlorosis and *Marasmius sacchari*.

Examination has also been made many times of cane stools whose roots were injured by the white grub or the root weevil. Affected roots of this sort also usually show the root fungus. Supposedly the injury would give a free entrance to the fungus, but on the contrary, it is also true that the root fungus is common on roots not apparently injured by insects.

In connection with studies of the mottling disease, while con-

siderable root disease has been found, the lack of evidence of the presence of *Marasmius sacchari* in any amount, transfers the discussion to the account of the mottling disease itself.

Injury.—The injury caused is primarily upon the roots. The mycelium enters the roots, distintegrates the tissues and prevents a proper absorption of water and nutriment from the soil. As a result of this injury to the roots there is the secondary effect upon the development of the plant. According as the attack is sever or mild, the host shows a varying amount of leaf curling, a dwarfing of the stool, and often an early succumbing to less vigorous parasites such as *Melanconium*.

Injury to the roots can be ascertained by direct examination, a slow tedious process, or to a certain extent can be diagnosed by symptoms above ground. The fungus itself eventually appears on the cane above ground, growing within and upon the lower leaf-sheaths, some times one-half or two-thirds the height of the stalk. The external appearance is a white myeelial growth, which is conspicuous by its rather smooth membranous appearance in contrast to a distinctly filamentous growth. Tearing away the affected leaf-sheaths reveals the fact that they are decayed, and are glued together as it were by the membranous growth, to the underlying sheaths and the stalk. The decay of the lower leaf-sheaths may not in itself be of great importance, but the binding of the leaf-sheath to the stem is very undesirable from the point of view of the mill worker who prefers clean cane.

This fungus, like some others, appears to make great headway when once it has attained a strong foothold on the host. Thus the fungus may develop well on plant cane without doing appreciable injury, but may so increase its foothold on the ratoons as to do double the injury. As a result of this action it is a common sequence that plant crops are fair in certain localities, the first ratoon is considerably poorer, and the second ratoon often dies out completely. The damage may be restricted to one or a few stalks in a stool, or more commonly it may affect an entire stool as well as one or more adjacent stools to form the characteristic disease spots, or more rarely large portions of fields are entirely affected.

The injury to the plant may be considered threefold: the growth of the plant is checked often to the point where no merchantable cane is produced, the matter of clean cane is rendered difficult, and the cane becomes more susceptible to other diseases.

Loss.—To estimate the loss caused by a disease of this nature is always a complicated matter and for that reason usually highly unsat-

isfactory. Cane diseased with *Marasmius sacchari* may also be affected by poor soil, poor cultivation, drought, insect injury, and other fungi, and therefore to distinguish the injury done directly by the root fungus is almost impossible.

In general terms, some idea of the tremendous loss that may safely be attributed to this fungus can be given. In certain areas on the north coast in the district from Canóvanas to and beyond Río Grande, it is in some years impossible to obtain more than one ratoon crop, and in one large area the plant crop was a failure, largely owing to a decay of the roots due to this fungus. In a certain area of a few acres, in the Fajardo district in 1913, the plant crop refused to develop normally, at nine months of age appearing no larger than the normal cane at three months should. In adjacent areas in hill land third ratoons were a failure over several hundred acres.

On the south coast not far from Ponce in 1911, a large area of Otaheite cane failed to give a plant crop. Fields to a total extent of several hundreds of acres have been investigated (Report 1914–15) during the past two seasons in the Juncos, Fajardo, Toa, and Añasco districts where the cane had been practically destroyed by root disease, aided by unfavorable weather.

Host Plants.—In order to thoroughly work out control methods, it is essential to know on what plants other than sugar cane the fungus occurs, if any. *Marasmius sacchari* has been definitely collected on wild pineapple, (*Bromelia pinguin*), on the common *malojilla* or Para grass (*Panicum barbinode*), on *Andropogon bicornis*, and on rotting coconut husks. The sporophores were found abundantly on wild pineapple leaves that were still upright but badly diseased from some cause. The plants were heavily covered with vines creating a very damp situation. The material on the *malojilla* occurred in a similar situation. It is not, however, considered that the fungus was the cause of any disease on these plants, but rather that it was present as a mere saprophyte in which condition it is very common on cane trash.

Occurrence in other countries.—Lewton-Brain (55) gave the first description of the fungus in the West Indies, together with an illustration. Since then there have been many references to the occurrence of this fungus in various parts of the British Islands, and they may be found in the publications of the Imperial Department of Agriculture and of the various local departments. They include reports from Barbados, Trinidad, St. Vincent, St. Lucia, Dominica, Antigua, St. Kitts, Nevis, Virgin Islands, Grenada, and Monserrat. In British Guiana the disease was first definitely studied by Bancroft (7) although first reported by Stockdale. Bancroft's account deals

with the history, symptoms, and prevention of the disease which had in some districts proven serious.

The occurrence of the fungus in St. Croix, American Virgin Islands, is noted by Dr. Longfield Smith (68, 69) in his annual reports. It has been collected by the senior author in Santo Domingo.

Horne (39) reported in 1909 *Marasmius sacchari* as occurring in Cuba. He states that, "Vigorous first-year canes may have the lower leaf-sheaths matted together with fungus and show no sign of injury, while plants attacked at the root may not have the sheaths matted." Symptoms of the disease are rather fully described and recommendations are given for its eradication.

Root disease was first reported from Hawaii by Lewton-Brain in 1905 but was not definitely determined as due to *Marasmius sacchari*. Cobb (14, 15) reported a variety of *Marasmius sacchari* which he named var. *Hawaiiensis*. His description, however, agrees so well in detail with that of the West Indian material seen by the authors that it is believed to be identical with it, and typical of *M. sacchari* rather than a true variety. The damage done by the fungus is given as considerable.

This fungus has been described in several publications (90, 91) from the Javan Stations, and also in Kruger's "Das Zuckerrohr und Seine Kultur," and Wakker and Went's "De Ziekten van het Suikerriet op Java." Injury caused by this fungus was said to be serious in the seed beds and in the growing cane. The description of the Java fungus differs from that of the West Indian in a few details but it is generally understood at present that they represent the same species. *Marasmius* is given as the cause of one of the more important cane diseases of Mauritius by Stockdale (78).

Description.—As ordinarily seen in the field *Marasmius sacchari* is represented only by the white mycelium at the base of the stalks. During periods of rainy weather, however, the distinctive fruiting bodies also appear. These are small, more or less umbrella-shaped mushrooms, grayish-white in color, and growing near the base of the stalks on the outside of the leaf-sheaths. The top of the fungus varies from about one half inch to one and one-half inches in diameter.

The following is the technical description:

MARASMIUS SACCHARI Wakker.

Gregarious or fasciculate at the base, persistent, fleshy-membranous; pileus white, widely campanulate, then dingy white, plane or cup-shaped; 15 mm. diam.; lamellae white, simple or bifurcate; stipe central, white, 15 mm. long, tubiform at apex, villous at the base.

Hyphae white, sporidia hyaline, continuous, irregularly oblong, everywhere attenuate, rotundate, 16–20x4–5 mu.

PORTO RICO.—On cane, Ponce, June 8, 1911, 4062,[1] 4063; Fortuna, June 10, 1911, 4064; Río Piedras, Aug. 19, 1912, 4530, Sept. 19, 1912, 4597, Sept. 25, 1912, 4615; Canóvanas, Oct. 10, 1912, 4627; Mameyes, Dec. 3, 1912, 4691; Río Piedras, 1915, 3051, 3168. On *Panicum barbinode*, Cambalache, May 19, 1911, 4060; Patillas, Jan. 30, 1913, *D. L. Van Dine*. On *Bromelia pinguin*, Río Piedras, Nov. 12, 1912, 4730. On *Andropogon bicornis*, Río Piedras, May 30, 1914. On coconut husk, Santurce, *Mrs. E. G. Britton*, Feb. 12, 1914, 1471. Also collected a number of other times at Santa Isabel, Loíza, Carolina, Fajardo, Juncos, Camuy, Quebradillas, Toa Baja and Río Piedras. Of common occurrence in all parts of the Island. (Pl. XX, fig. 1; pl. XXVI, figs. 8, 9, 10.)

THE STELLATE-CRYSTAL FUNGUS (*Himantia stellifera*).

There is probably no form more common on cane in Porto Rico than the so-called stellate-crystal fungus which is commonly found at the base of the stalks, cementing together the leaf-sheaths, as do other species growing in this situation, and penetrating the roots as well. Although of such constant occurrence the question of its parasitism is as yet doubtful and will remain so until studies under controlled conditions of this form in comparison with other root fungi can be carried out.

Field observations have demonstrated its presence on a considerable range of plants other than cane, particularly those grasses which have a similar habit of growth. It has been found externally at the base of the following plants:

Andropogon bicornis	*Paspalum plicatulum*
Cymbopogon citratus	*Paspalum schreberianum*
Cyperus sphacelatus	*Paspalum underwoodii*
Dichromena ciliata	*Paspalum virgatum*
Heliotropium indicum	*Ryncospora cyperoides*
Panicum laxum	*Sporobolus jacquemontii*
Panicum maximum	*Stenotaphrum secundatum*
Paspalum paniculatum	*Syntherisma digitata*

The first mention of this fungus outside of Porto Rico is by Lewton-Brain (57) who described and figured it in connection with

[1] In the citations in this paper all collections up to September, 1913 (accession numbers 4000–5000) are by the senior author, those from that date until July, 1914 (accession numbers 1000–2100), are joint collections and all since that time, (accession numbers 2100–6500, omitting the 4000 series) by the junior author, unless otherwise stated. Specimens of all collections, except of some of the earlier numbers, are deposited in the herbarium of the Insular Experiment Station, Río Piedras, Porto Rico, and in so far as duplicate material was available in the herbarium of the New York Botanical Garden.

his studies on root disease in Hawaii. It was again mentioned by Cobb (15) in a succeeding Hawaiian bulletin. In neither instance was it named, although a possible connection with *Marasmius sacchari* was suggested. Bancroft (7) in British Guiana in reporting on a root disease which he attributed to *Marasmius*, mentions stellate crystals as one of the characteristics of the mycelium. What is apparently the same fungus was reported from Porto Rico by Fawcett (26), from St. Croix by Longfield Smith (69, 70) and from Jamaica by Ashby (3).

The presence of this fungus on other plants than cane suggests an error in the current method of combating root disease, the turning of the land to pasture. It will be much more effective to plant a legume (cowpeas or velvet beans), and so starve out the fungus.

Himantia stellifera Johnston sp. nov.

Mycelium cob-webby, or somewhat dentritic, white, ascending the lower leaf-sheaths and penetrating the roots. Hyphae with clamp conections, and bearing on short side branches stellate crystals of calcium oxalate. No fruiting bodies known.

Differs from *Himantia sacchari* Speg. and *Himantia guttulifera* Speg. in the presence of the stellate crystals as well as in other essential points.

PORTO RICO.—On cane, Río Piedras, Jan. 12, 1914, 1183, (type); Juncos, Aug. 23; 1915, 3050; Cambalache, March, 1914, 5136. On Cymbopogon citratus. Río Piedras, Oct. 26, 1914, 2282, Oct. 1915, 3212. Collected or observed on cane and many other hosts commonly in all parts of Porto Rico. (Pl. XIX, fig. 2; pl. XXXI, figs. 1–4.)

THE GRANULAR LEAF-SHEATH FUNGUS (*Odontia saccharicola*).

This is a very common fungus occurring at the base of cane stalks binding. (as is usual with fungi of this nature) the lower leaf-sheaths firmly together and to the stalk itself as well, so as to make their removal difficult. Whether or not the fungus penetrates below ground to the extent of attacking the roots is a point which it has not yet been possible to investigate. The only visible damage is the rotting of the leaf-sheaths which are permeated by the white mycelial elements. Fruiting areas occur as uniform thin white patches with a granular somewhat powdery surface encircling the stalk from the ground level to a height of eight inches or a foot. (Pl. XIX, fig. 1.)

This fungus is very commonly found on all varieties of cane and occurs apparently independent of whether the stool is healthy or otherwise. It is very common on canes attacked by the mottling

disease but no more so than the canes in the Experiment Station fields. In all studies of root disease made heretofore, however, this form has been beyond much doubt confused with other forms present, and the presence of root disease has been assumed where it occurred.

This form may easily be confused with the much less common species *O. sacchari*, which is treated under minor fungi. To quote Dr. Burt, "*O. saccharicola* is thinner and is composed of shorter-celled hyphae which are not suberect, not nodose-septate and do not bear spores in the interior of the fructification. The stellate crystals are present abundantly in all specimens * * * and appear to be of aid for recognition of this species."

ODONTIA SACCHARICOLA Burt. Mo. Bot. Garden 4, No. 3. 1917.

Fructification resupinate, effused, adnate, very thin, pulverulent, not cracked, whitish, drying cartridge-buff, the margin narrow and thinning out, granules minute but distinct, about 6–9 to a mm., in structure 30–50 mu. thick with the granules extending 45–60 mu. more, composed of loosely and somewhat horizontally arranged branched, short-celled hyphae, 2.5–3 mu. in diameter, not nodose-septate, not incrusted but having in the spaces between hyphae numerous stellate crystals 4.5–7.5 mu. in diameter from tip of ray to tip of opposite ray, cystidia hair-like, flexuous, not incrusted, septate, weak, often collapsed, tapering upward to a sharp point, 1.5–3 mu. in diameter, protruding 8–18 mu., about 1–3 to a granule at the apex; basidia simple, cylindric-clavate, with 4 sterigmata; basidiospores hyaline, even 5.5 X 5.5 mu., flattened on one side. *Dr. Burt's description.*

PORTO RICO.—On cane. Vega Alta, July 5, 1912, 4525; Río Piedras, Jan. 9, 1914, 1172, Jan. 13, 1914, 1184, Jan. 1915, 2657, 2657-*a*, Oct. 5, 1915, 3176, Dec. 1915, 3617, Feb. 9, 1917, 6193, July, 1917, 6589; Canóvanas, June, 1916, 5502. Also observed at Juncos, Toa Baja, Camuy, Quebradillas, Arecibo, and Fajardo. Very common everywhere. Original determination by Dr. Burt, 1916. (Pl. XIX, fig. 1.)

The exact status of root disease with respect to the parasitism of *Marasmius*, *Himantia*, *Odontia*, or possibly other forms is uncertain and while it is generally held that *Marasmius* at least is a true parasite, really definite evidence is lacking. Studies under controlled conditions must be carried out working with pure cultures of the fungi, which has not yet been possible. As is the case with so much of the work in tropical pathology to date, root disease studies of a necessity have consisted of field observations only, valuable in as far as they go, but hardly to be used as a basis for exact determinations of matters of parasitism.

It has been suggested, and it is believed with good basis, that *Odontia saccharicola* is the perfect stage of *Himantia stellifera*. This possibility affords a further point to be included in the above proposed investigations. The presence of stellate crystals in the fruiting bodies as reported by Dr. Burt affords further evidence of such a connection.

The need of a greenhouse (a lack which has now been remedied) from which wind and insects can be excluded and where moisture supply and other factors can be controlled to a large extent has been one reason preventing careful studies of root disease up to this time. Pot cultures in the open have proven very disappointing, and more often than not complete failures.

ROOT-KNOT (*Heterodera radicicola* [Greef] Müll.)

While not due to the work of a fungus, some mention of root-knot for the sake of completeness is desirable in a paper of this nature. Although a considerable number of economic plants suffer from nematode attack in Porto Rico (75, 76) particularly some of the vegetables, cane in so far as observed suffers but little. In one instance a considerable amount of infestation was found in 1915 in certain fields near Juncos which were suffering from unfavorable weather conditions, and a rotting of old stools (root disease). So many conditions were involved that it was impossible to say as to whether the nematodes were playing any large part in the destruction of the cane. In experimental plantings artificially infested by burying typical root-knot material from *Coleus*, only slight infestations resulted. Root-knot apparently does not threaten any great amount of harm to cane in Porto Rico. Other species of nematodes have not been encountered.

PORTO RICO.—On cane, Juncos, July 29, 1915, 2934; Río Piedras, 1917. Also collected on a wide range of other hosts, reported in other publications (75, 76).

DISEASES OF THE STALK.

THE RED ROT (*Colletotrichum falcatum*).

The red rot or red smut as it is known in Java can hardly be considered as one of the serious cane diseases of Porto Rico, although the fungus causing it is one of the most common forms encountered, usually as a saprophyte. As a parasite it attacks the stalk and leaves causing in the first instance an internal red rot, and in the second

a red stripe of the mid-rib. This latter phase is discussed in detail under leaf diseases.

Occurrence in other countries.—*Colletotrichum falcatum* was first reported and described from Java in 1893 by Went (93, 94), and has been treated in great detail by Wakker, Went, and other workers (53, 97, 98), in that country, where it is considered one of the most serious of cane diseases. Its parasitism was proven by inoculations and life history studies were carried out.

The disease has been of equal, if not greater importance in British India and in fact a perusal of the literature leads to the conclusion that it is far and away the most serious cane disease of that part of the world. Butler (10, 11) has carried out extensive and conclusive studies with this disease, although the first report was by Barber (8), who noted that the disease was apparently parasitic in one district and saprophytic in another. Butler's investigations led him to believe that the fungus was readily transmissible from cutting to shoot, and that this was the chief method of infection of growing cane.

Lewton-Brain (59) gave a complete account of the disease reporting, however, that in Hawaii it was of little importance.

In the southern United States, Edgerton (23, 24, 25) has investigated red rot in Louisiana and reports finding a loss in stand due to the killing of young plants and decrease in per cent of sucrose through inversion by the action of the fungus. Fawcett (27, 28) reported the fungus from Florida and the senior author has observed it in Florida, Georgia, Louisiana, and Texas.

Considerable work has been carried out with this fungus in the West Indies. Howard (43, 44) in particular conducted studies with it, maintaining that it and not *Melanconium* was the cause of rind disease. He describes the disease as follows: "The disease appears about four or five months before the canes are cut, generally at the beginning of the ripening period. * * * The first outward symtom of the malady is the drying up of the leaves which commences at the margins of the older ones, and gradually spreads to the center of the tuft in from four to six weeks. When this drying of the leaves is well marked, the stem of the cane shows a brown discoloration in one or more places, after which the rind shrivels up, and the discoloration rapidly extends in all directions. On splitting such canes, the tissues are seen to be of a reddish color, in which darker red areas can be seen. Very frequently these darker regions contain definite white centers, elliptical in vertical section."

South and Dunlop (72) present a review of the literature and the results of inoculation experiments carried out by them in Barbados

and St. Kitts. They concluded that the fungus is merely a facultative wound parasite, gaining entrance largely through borer holes, and that the disease was not communicated by infected cuttings.

In addition to the above there are reports of occurrence by South (70, 71), Ballou (4), Nowell (64, 65), and Dash (18), in Barbados, Antigua, St. Kitts, and St. Lucia. The senior author reported (49) it from Santo Domingo. It is mentioned by Averna Sacca (100) as one of the cane diseases of Brazil.

Tryon (87) mentions red rot as one of the cane diseases of Queensland and Stockdale (78) in reports of the agricultural department of Mauritius gives an account of its occurrence on that Island.

Red Rot in Porto Rico.—The losses due to this fungus in Porto Rico in no way compared with those reported from other countries. It is of interest to note that this fungus, which occurs in most cane countries, varies greatly in its virulence as indicated in the discussion above, Porto Rico being one of the regions in which it is for the most part a wound parasite only. In a very few instances it has, in connection with a lack of water, destroyed cane over small areas, one field of less than one hundred acres being the only serious case observed. There are indirect losses through a decrease in effective leaf surface, and through its growth in connection with borer injury, or *Melanconium* and other fungi, but these are of such a nature that it is impossible to give any estimates.

The fungus very commonly occurs in stalks injured by the moth stalk-borer (*Diatraea saccharalis*) or other causes, producing a red discoloration internally, but no external symtoms, at least as long as the cane remains green. Development of the fungus may be fast or slow according to the variety and the vigor of the cane. The damage caused is, however, more than is apparent since the fungus very quickly inverts the sucrose to a considerable extent, raising the glucose ratio. The relation of *Colletotrichum* to the inversion of sucrose has been considered by all of the various workers who have investigated the matter to any extent, and all have agreed that this represents the serious phase of the disease.

To a more limited extent, the fungus occurs independent of borer holes but it is generally possible in such instances to find some other weakening influence, drought, root disease, or other fungi. It frequently happens that young shoots are crowded out by more vigorous ones in a stool and wither away, and in such cases this fungus may commonly be found, although, even then, the moth-borer, or other insect or root disease may be the initial cause. Where large areas of cane are attacked it has generally been found that there have

been pre-disposing causes, particularly drought. *Colletotrichum* is often found following after the rind disease, that is in so far as external appearances show. As to which is primary internally appears to be immaterial, sometimes one appearing first and sometimes the other. Both are considered wound parasites or as capable of attacking weakened canes only. A further note on the occurrence of this fungus will be given under "Diseases of Cuttings."

There are other forms which are morphologically similar to *Colletotrichum falcatum*. For this reason the finding of what is supposed to be *C. falcatum* on other plants should be demonstrated by cross-inoculations. It has not as yet been proven that this fungus does occur on other plants. Edgerton (25) has attempted by cross-inoculations to ascertain whether *C. lincola* on Johnson grass (*Holcus halepense*) may not be the same as *C. falcatum* on cane, as it appears to be morphologically, but as yet he has been unsuccessful in this.

Although not definitely proven to be *C. falcatum* a form identical with it in appearance has been found on dead leaf-stalks of the common papaya (*Carica papaya*). As a matter of fact more than one form has been found on cane, as is noted on another page, and until more is known about the relationships of these various forms the question of the occurrence of *C. falcatum* on other plants can not be satisfactorily determined.

Description of Colletotrichum falcatum.—The fungus produces an internal red rot of attacked canes, often limited in otherwise healthy stalks to the injured internodes only, but in more severe cases progressing up and down the stalk, more rapidly along the vascular bundles than in the surrounding tissues. After the rot has progressed some time characteristic whitened spots appear in the center of the red areas. Beyond a withering of the leaves no other symptoms are present. The fungus does not fruit until the stalk has become dead and thoroughly rotted, when it produces black velvety patches on the surface more generally near the nodes. It is very common to find the fungus fruiting on dead leaves, or on the margins and tips of leaves which are dying.

COLLETOTRICHUM FALCATUM Went.

With setae sometimes seriate, sometime congregate in a pseudo-conceptacle, 100–200 X 4 mu., sooty, pale above; conidia falcate 25 X 4 mu., at the base of the setae supported by basidia, ovoid, 20 X 8 microns, hyaline or dark.

PORTO RICO.—On cane Río Piedras, April 10, 1911, 4050, April 21, 1911, 4055, June 5, 1911, 4068, April 20, 1912, 4336, May, 1912.

4334, 4342, May, 1912, 4351, Feb. 3, 1914, 1342, Nov. 28, 1916, 5816, Feb., 1917, 6313, 6403; Ponce, Jan. 11, 1912, 4150, 4155, 4160; Fortuna, April 27, 1912, 4356; Fajardo, March 25, 1912, 4292; Yauco, March, 1912, 4299, 4300; Canóvanas, May 29, 1912, 4343; Carolina, Jan. 9, 1915, 2521. On *Carica papaya,* Río Piedras, Oct. 24, 1912, 4645, Dec. 1912, 4731. Common in all parts of the Island on dead and dying cane stalks and leaves. (Pl. XX, fig. 4; pl. XXVIII, fig. 9, 13, 14, 16, 17.)

RIND DISEASE (*Melanconium sacchari*).

The rind disease of cane has been the subject of a paper recently published in this JOURNAL (52) and was there treated in such detail as to make it unnecessary to give more than a summary for the sake of completeness in the present account.

Rind disease has been reported and studied under a variety of names and with much confusion with other fungi, (in particular with *Thielaviopsis*), in practically all of the cane growing countries of the world, including Louisiana, Georgia, Texas, Florida, Cuba, Jamaica, British Guiana, Barbados, Trinidad, St. Vincent, Antigua, Grenada, St. Lucia, Nevis, Argentina, Brazil, Mauritius, Java, Indo-China, Queensland, New South Wales, and Hawaii. In some instances it has been considered as a serious parasite, and in particular has been held to be the cause of a serious epidemic of disease which nearly destroyed the cane industry of Barbados in 1895–99. Most workers are now agreed, however, that as a general rule *Melanconium* is but a wound parasite or an enemy of weakened or over-mature canes. This view is held for Porto Rican conditions where it is one of the commonest, if not the commonest fungus present in the cane fields.

Circumstances under which the rind fungus have been noted in Porto Rico are extremely variable. It has never been observed in fields of young green cane excepting in shoots injured or killed by some other fungus such as *Marasmius sacchari* or by such insects as the changa, white grub, or the moth stalk-borer. In such cases it is certainly only a saprophyte.

In cane of six or eight months, it can commonly be found on the leaf-sheaths of many stalks and especially on certain varieties. The fungus occurs not only at the base on the outside of the leaf-sheath but occasionally near the union of the leaf-sheath with the leaf-blade. On the leaf-sheaths it may hasten the dying of the leaf but does not necessarily pass from the sheath into the stalk. Numerous canes have been watched to maturity, which remained perfectly healthy as far

as the stalks were concerned, but which had had the fungus on the leaf-sheaths for some months.

In contrast to these conditions, damage which can be attributed to *Melanconium* has been observed, where weak varieties or over-mature cane was involved. A variety known as D–625 has been particularly noted suffering with typical rind disease, moth-borer or other fungi not being present in sufficient amount to account for the loss. It has also been a common experience to have fields, which had been left over from one crop season to the next, either because it was hoped the yield would be increased, or because it was impossible to cut them before the grinding season closed, destroyed or rendered worthless as far as the yield of sugar was concerned. Rayada, white (Otaheite) and D–625 have been noted suffering in this manner.

In addition to attacking over-mature cane, it is not uncommon to be preceded by a weakening of the vitality of the cane through the presence of the root disease, or some untoward soil condition. This is especially true in old ratoons that are "running out," and instances have been seen where such a state of affairs resulted in total loss.

In all cases in Porto Rico an infection with the rind fungus seems to be preceded by a weakening of the vitality of the cane through some other unfavorable condition. Unfortunately these conditions can not always be foreseen, and therefore rind disease must be considered as something of an obstacle to continuous good yields in spite of its lack of a truly parasitic nature. In general, however, the use of hardy varieties, not allowed to become over-mature and properly cultivated, will avoid any serious loss from this malady.

The fungus will be further considered as a disease of cuttings under that heading.

Description.—The fungus produces a souring of the juice and a soft white rot of the tissues, affected stalks withering and drying up. Fruiting pustules form in great numbers on thoroughly rotted stalks or on the base of leaf-sheaths, appearing first as small black slightly raised areas, several times longer than broad. The epiderm covering these is soon ruptured permitting the black spore mass to exude which, depending upon the moisture present, varies in shape from a flattened mass to long thread-like processes.

MELANCONIUM SACCHARI Massee.

Conidia produced in pycnidia (acervuli) formed under the epidermis, unicellular, pale brown, cylindrical, straight or curved, 14–15 X 3.5–4 mu.: conidia extruded in long black cirrhi.

Porto Rico.—On cane, Yabucoa, March 27, 1911, 4040; Río Piedras. April, 1911, 4052, 4056, June 5, 1911, 4066, Feb. 10, 1912, 4211, March 25, 1911, 4295, April 14, 1912, 4340; Fortuna, April 27, 1912, 4356; Jan. 10, 1912, 4152; Aguadilla, April 7, 1916, 5135; Camuy, Jan. 4, 1917, 6074. Very common in all parts of the Island. Observed but not collected at Fajardo, Canóvanas, Carolina, Juncos, Arecibo, Barceloneta, Central Alianza, Quebradillas, Utuado, Isabela, Añasco, Guánica, Vega Baja, Toa Baja, Bayamón. (Pl. XX, fig. 3; pl. XXXI, fig. 7.)

CYTOSPORA SACCHARI.

This is a comparatively new disease of cane for which no common name has as yet been proposed. It was first found in February, 1912, by the senior author on dead cuttings of various Barbados seedlings at Río Piedras. In succeeding months it was noted on dead stalks of other varieties of the same origen, and in 1913 was discovered at Fajardo, again on Barbados seedlings. In this instance, it was causing some loss. Still later investigations were made in this locality, the disease having spread to other varieties and occasioned some alarm. The only other locality in which the fungus has been seen to date is Carolina where in 1914 a small infected area in *rayada* (striped) cane was observed. The varieties which have suffered injury have been the softer white canes and for the most part introduced varieties. It would appear that the disease had been brought in on some one of these prior to the establishing of the plant quarantine.

The following varieties have been found infected to date, Rayada, B–7169, B–6385, B–1753, B–8660, B–7245, B–3696, B–3859, B–1355, B–3922, D–109, D–117, G. C.–759, and G. C.–47. Of these B–3922 and B–3696 have been most severely attacked.

The first report of the occurrence of *Cytospora* is from British India. Butler (10) who originally described the fungus stated that "on one stool examined the stem at one of the upper internodes was affected and the fungus was present on the leaf-sheaths as well." For the most part, however, it was merely a saprophyte. Averna-Sacca (100) has recently given an account of a disease which he ascribes to this same fungus, occurring in the State of Sao Paulo, Brazil. He claims to have found the perfect stage, but without having made any pure culture studies. His results are considered very doubtful.

The symptoms of the disease are very marked. Young shoots are killed outright, others checked in their growth, and the lower

leaves prematurely killed. The leaf-sheaths are bound firmly together by the mycelium, so that the shedding of the lower leaves one by one as occurs normally with most varieties or at least their loose adherence to the stalk only, does not take place. The leaf blades bend over at the junction with the sheath and hang parallel to the stalk giving diseased stools a most characteristic appearance. All exposed portions of leaf-sheaths are a very dark dull red, darker than the color produced by *Cercospora vaginae*, as well as more uniform as to area covered. The orange-red discoloration produced by *Sclerotium Rolfsii* could hardly be confused with it, even if sclerotia were absent. The reddened area is profusely covered with the fruiting bodies, the comparatively long pointed necks of which project beyond the surface sufficiently to be readily seen, and to give a rough sensation when the finger is rubbed over them. During wet weather a minute yellowish globule of conidia can be seen with a hand lens, exuding from the mouth of the beak of each pycnidium.

A more serious effect of the fungus is its attack on the stalks of certain susceptible varieties. Young stalks are very quickly killed and in fact those of some size are often overcome, in particular any that have not formed any hardened internodes. The fungus produces a dry rot which of course renders the cane worthless for sugar production. On canes which are mature or nearly mature, very typical cankers or lesions are produced. These may be one, or several on each internode, and they are often confluent so as to completely encircle the stalk. Infection apparently occurs through the leaf traces from infected leaves since the lesions in practically every case commence at the nodes and spread downward along the internodes. One or more infections may occur at each node, but never extend over more than one internode except in advanced stages, where fusion of the separate diseased areas occurs. An exception to the manner of entrance of the fungus occurs along cracks, which are commonly present in the soft white varieties. Nodal infections take on a very characteristic shape, that of an inverted cone with a blunt point, the broad base lying along the node, and the point extending down toward the node below. The diseased areas have regular margins except toward the apex and are a deep brown in color, lighter toward the lower end. The most advanced portions present merely a water soaked appearance of the tissues. The lesions are slightly sunken in the older portions, or near the nodes, and along any cracks that may appear. The cracking in itself is not considered a symptom since it is a phenomenon which occurs naturally in many varieties and also accompanies a number of other diseases. The brown coloration ex-

tends into the tissues a short distance only, rarely more than an eighth of an inch. Rind disease very often completes the destruction of the attacked stalk.

Because of the fact that this fungus, a saprophyte only in other parts of the world, was acting as a virulent parasite in Porto Rico towards several varieties, fears were entertained that it might become epidemic. However, there has been in the past year no further spread and it would appear that the disease had reached its limit. The susceptible varieties growing at Río Piedras have been eliminated and there are at present no signs of the fungus. A similar procedure was recommended for the other localities known to be infected.

CYTOSPORA SACCHARI Butler.

Stromata verruciform, arranged in rows, erumpent, plurilocular, black, ostiole elongate, single, rarely double; sporules minute, cylindrical, slighty curved, obtuse at both ends, 3.5 X 1–1.5 mu.; basidia branching, septate, 12–18 mu. *Description after Butler.*

PORTO RICO.—On cane, Río Piedras, Feb. 1912, 4280, May 24, 1912, 4352, Aug. 1912, 4335, July 10, 1912, 4656, Jan. 15, 1914, 1646, Oct. 1915, 3217; Carolina, Feb. 18, 1914, 1408; Fajardo, July 6, 1913, 4983, Aug. 4, 1913, 1012, Dec. 30, 1914, 2526, June 14, 1915, 2829, Dec. 27, 1916, 5907. (On leaf-sheaths, and stalks of living cane. Pl. XXII, figs. 1, 2; pl. XXVIII, figs. 1–4.)

TOP-ROT.

This is a term that has been employed to some extent in the literature and is used by a great many planters to indicate a diseased condition of the top. Considerable attention has been given to this disease in Porto Rico but up to date it has not been possible to arrive with any certainty as to the cause. When a stalk is badly injured by the moth stalk-borer, the top ultimately dies and in the rotten mass at the center will be found small borers, fly larvae, etc. This is the most common type of top-rot found in Porto Rico, and is clearly due to the borer. It is, however, quite possible to find dead tops or "dead hearts" as they are called locally, which do not show any signs of insect work. In fact a former entomologist of this Station in the course of his studies of *Diatraea* reported that a considerable proportion of "dead hearts" examined by him were not due to the borer. Cultures of such cases have yielded bacteria and several types of fungi, none of which have produced any results upon inoculation.

The senior writer observed a plantation in Texas in which the

cane was growing poorly, and where the stalks with dead tops were very numerous. The dead tops showed at the heart a soft white putrid mass indicating a bacterial rot. Borers were present in the stalks but not in the tops.

Top-rot has been reported in Java but no definite conclusions were reached as to its cause, nor was it clearly diagnosed as a specific disease.

DISEASES OF THE LEAF.

THE RED SPOT OF THE LEAF-SHEATH (*Cercospora vaginae*).

The red spot of the leaf-sheath is an extremely common disease of many varieties of cane, so much so in fact that the reddening of the lower leaf-sheaths becomes almost a distinguishing character of some types. Infection occurs on the upper sheaths while they are still green and closely appressed to the stalk. The areas are at first quite regular in shape, bright red in color, and sharply set off from the normal green tissues surrounding. They increase in size rapidly, becoming irregular in shape, and finally cover the larger portion of the sheath. The fungus not only spreads over a given leaf-sheath but invades those beneath, the area attacked on each successively becoming smaller and smaller as it passes toward the center. However, several to many points of infection may be set up on each sheath. This action is sufficient to insure the spread of the disease to all the leaves of any one stalk. The leaf blades have not been found subject to attack. Occasional lesions ascribed to this fungus are found on the stalks. Fruiting areas occur as black patches often several inches in diameter at the center of the infected regions of the outer sheaths.

This disease has been reported from the West Indies by Bancroft (5, 6), from Java by Wakker (92), and by Kruger and Went (53), and from Reunion by Colson in his work on the sugar industry of that island.

As is the case with so many leaf diseases it is somewhat difficult to make any definite statements as to the amount of damage caused. It ordinarily passes without notice, and is in fact considered a natural phase of the growth of the cane by most planters, but it is certain that it is responsible for some decrease in sugar content because of its action in bringing about a premature death of the leaves.

Such experiments as have been carried out during two seasons were contradictory. In the experiment of 1911, cuttings of Cristalina cane were used, all badly diseased. One hundred of these were

planted without the removal of the diseased sheaths and two hundred were planted after stripping. The germination was as follows, counting shoots per hundred seed, the planting being made March 27:

	April 17	April 24	May 1	May 13	May 24
Sheaths removed	13	64	104	156	158
Sheaths not removed	69	167	206	229	241

This apparently showed that better germination followed non-removal and that red spot did no injury. In the mature cane of this planting there was no difference in the respective amounts of the disease present.

In the experiment of 1913, three hundred seed with the leaf-sheaths on and three hundred with them removed were planted in alternate rows of one hundred and fifty seed each. At the end of the counts of the germination, the two rows planted with the sheath on gave seven hundred and eight shoots, the other two rows one thousand and three, a result exactly opposite to that obtained the first year. In the latter experiment the leaf sheaths may have presented a mechanical obstruction to germination. The use of a different variety (Otaheite) may also explain the difference in part. Subsequent growth showed no observable difference in the amount of disease present on the two lots.

There is a very marked varietal resistance to the fungus. Cristallina and B–1753 are usually badly affected, Otaheite somewhat less and yellow Caledonia, D–116, and the red or purple canes such as cavengerie, etc., are seldom much infected. It can not be determined that the amount of infection shows any definite relation to the so-called hardiness of the variety. No environmental conditions have been noted which appeared to have any connection with the amount of disease present.

Cercospora vaginae Krüger.

Hyphae dark, cobwebby, arising from the center of a red discoloration on the leaf-sheath; sporophores more or less erect, rigid or flexuous at the tip; spores solitary usually at the tip, occasionally borne on the side of the sporophore, one to several celled, 4–8 mu. x 15–40 mu.

Porto Rico.—On cane leaf-sheaths, Río Piedras, March, 1912, 4293, 4296; Los Caños, Dec. 8, 1911, 4118; Fajardo, March 25, 1912, 4290; Arecibo, March, 1916, 5088. Observed in all parts of the Island, on practically all varieties of cane. (Pl. XXIX, fig. 19, 20; pl. XXIV, fig. 1.)

RED ROT OF THE LEAF-SHEATH (*Sclerotium Rolfsii*).

This is again one of the diseases of cane which, though very common everywhere, has not been considered of economic importance. In fact there have been no observed cases of serious loss in cane fields attributable to this fungus in Porto Rico, although such instances have been reported from St. Croix and Georgia.

The fungus favors the more moist situations and apparently heavier soils. In cane fields it does not appear to any extent until the cane has closed in creating a moist situation. Upland fields show but little of the fungus, except in wet weather. It is not uncommon to find fields practically every stool of which shows an abundance of infection. It has not been possible even in such cases to observe that any damage was being done, the stand apparently being entirely normal. Young shoots will be commonly found dead and covered with the sclerotia, but the death of these young shoots occurs under all conditions and is considered a natural phenomenon due to smothering or lack of light or food. The lower leaf sheaths are undoubtedly prematurely killed, but since the fungus rarely attains to any height on the stalk the leaves so destroyed are those already shaded and hence rendered more or less useless, so that the injury due to reduction of leaf surface is considered negligible. Whether the fungus attacks the roots as it does those of other hosts is not known. This is a point which must be taken up along with a detailed study of the root disease fungi.

The fungus appears as a white, more or less feathery mycelium growing up the lower leaf-sheaths binding them together and producing a red rot of the infected tissues. The color of the rot is a bright orange-red quite distinct from that of *Cercospora vaginae* or of any other disease attacking at this point. The areas are very irregular, with indistinct margins, seldom extending over a foot or a foot and a half above the ground level. The only fruiting stage known consists of the sclerotia produced particularly along the edges of the leaf-sheaths, in the folds, or between two diseased sheaths and to a less extent on the reddened areas of the outer surface. They are first noticed as white, very small, masses of hyphae forming on the strands of mycelium. They finally become from one thirty-second to a sixteenth of an inch in diameter, more or less spherical, flattened at the poles. The color varies from white through yellow-brown to a very deep red-brown or brown, when mature. The sclerotia when mature are quite firm and but loosely attached to the substratum.

This fungus has been observed (76) as the cause of a serious wilt disease of various vegetable crops, particularly the egg-plant, pepper.

and tomato. It has been found causing a damping off of citrus seedlings and doubtless attacks a range of other hosts here, many others being reported from the Southern United States.

As a disease of cane *Sclerotium Rolfsii* was first studied and described from Java by Krüger (53). Howard (44) has reported it in Trinidad and Longfield Smith (70) in St. Croix. Mention of its occurrence is also made by Horne (39) in Cuba and Ashby (3) in Jamaica. The senior author has seen it in abundance in Florida, Georgia, Louisiana, and Texas.

PORTO RICO.—On cane, Hormigueros, July 17, 1911, 4070; Río Piedras, September 18, 1915, 3078, June, 1917, 6560. Observed in all sections of the Island. Also collected on *Lycopersicum esculentum, Capsicum annuum, Solanum melongena, Citrus sp.* (Pl. XXV, fig. 3.)

THE EYE-SPOT OF THE LEAF (*Helminthosporium sacchari*).

The leaf blades of the sugar cane are subject to a number of diseases, so commonly in fact, that a field of mature or nearly mature cane that does not show a large per cent of infected leaves is a rarity. Several fungi are concerned in producing the spotting, some more common in one section, others in other parts of the Island. Certain districts suffer much more than others, the Fajardo area for instance being much more free of leaf disease than some others. It is difficult if not impossible to make any statements as to the losses occasioned by these diseases since their effect is indirect. There is undoubtedly some loss due to the destruction of leaf surface, the amount varying with the per cent of infection, and the age of the cane when attacked. The exact relationships of the various fungi and resulting leaf spots have not been completely worked out, but such notes and observations as their economic importance warranted have been made.

One of the common types of leaf-spot is that called by some workers the "eye-spot." Several varying forms have been encountered, doubtless due to the varietal differences of the host or environmental factors. That most generally noted was one encountered very commonly in studies of the mottling disease in the Arecibo-Aguadilla region. The spots were a medium to dark brown in color, with definite margins, much longer than broad, from one to five millimeters in breadth, from one to five centimeters in length, very numerous, often coalescing, and very often the apparent cause of death of the leaf. In other instances the spots are elongate-oval not coalescing, or causing death of the leaf, medium brown in color, 2–4 mm. by 8–15 mm. Still a further type was encountered in which the spots were oval, about one by two centimeters, distinctly zoned, with a rather indefinite

margin, and yellowish brown in color. It has been observed on T. 77, Otaheite, Rayada, Sarangola, and in fact all varieties growing in the western end of the Island.

Helminthosporium sacchari has been reported (generally as *Cercospora sacchari*) from Hawaii (54), the Philippines by Barrett in 1911, Java (53, 93), Reunion, and British India (12). It was originally described by Van Breda de Haan and redescribed by Butler who placed it in its present genus. By none of these workers has any serious damage been attributed to it.

HELMINTHOSPORIUM SACCHARI Butler.

Cercospora sacchari Van Breda de Haan.

Hyphae dark, cobwebby, arising from the center of an elongate brown spot on the leaf-blade; sporophores more or less erect with single terminal spores; spores several septate with very thick walls, rounded at both ends, 32–90 X 9–14 microns, on conidiophores 120–160 mu. long.

PORTO RICO.—On cane leaves, Río Piedras, January 22, 1914, 1642, April, 1917, 6418, June, 1917, *R. C. Rose,* 6550: Camuy, Jan. 4, 1917, 6078; Quebradillas, December 1916, 5900. Original determination by J. A. S. (Pl. XXIX, fig. 4, 5.)

RING SPOT OF THE LEAF (*Leptosphaeria sacchari.*)

This is one of the most common cane fungi of Porto Rico. It is found in practically all cane fields, being usually most abundant on the windward side. Practically every variety will show some infection, although there is great variation in susceptibility, yellow Caledonia and the white bamboo for instance being quite free as a rule. The amount of disease present also varies in different sections of the Island. Some loss is occasioned by destruction of leaf surface, and in connection with poor growing conditions, or other weakening influences, there may be a heavy loss.

The spots produced by this fungus are usually very numerous, oval in outline, 5–10 millimeters in breadth by 7–15 in length, dull gray at the center with a definite red or red-brown margin several millimeters in width. There is often an indistinct yellow halo surrounding each spot. The spots not only have a tendency to coalesce but the tissue between turns yellow and the entire leaf as a result withers. This action, however, takes place slowly. Conidia are produced on the lower surface of the spots, obtuse angled, black, 3–5 septate, the central or two central cells being larger than the apical

ones. The perithecia appear as minute black immersed bodies at the center of old areas.

The disease was first described by Van Breda de Haan in West Java and was later treated in some detail by Wakker and Went (93). Butler gives an account of the disease as it occurs in British India (10) and Cobb (15) makes short mention of its presence in Hawaii. It has been reported several times from Cuba (38, 39) and is known to be present in the British West Indies (5). The senior author collected it in Santo Domingo. Averna-Sacca (100) gives an account of it as it occurs in Sao Paulo, Brazil.

Spegazzini (73) describes two species of *Leptosphaeria* on cane as new, but neither fits the description of the present species although one is called *L. sacchari* Speg. Neither produced definite spots, nor was more than a dweller on dead leaves or stalks.

A smaller leaf spot very closely resembling that just described occurs to a limited extent but has not been found in fruiting condition. It may in fact be only an abnormal type of the *Leptosphaeria* spot. What is apparently the same thing has been mentioned in Cuban publications (39). (Pl. XXV, fig. 12.)

LEPTOSPHAERIA SACCHARI van Breda de Haan

Hyphae hyaline to dark, hypogenous, arising from oval gray spots, unbranched: conidia dark, 3–5 septate, obtusely angled, central cell larger than apical cells, 20 X 9 mu. Perithecia minute, 120–150 mu. diameter, black, formed beneath the stomata, paraphysate; spores 3-septate, center cells larger than apical cells, 20–24 X 5 mu., brownish. Producing a leaf spot of cane. Description after Butler.

PORTO RICO.—On living cane leaves, Juncos, July 27, 1915, 2924; Río Piedras, Nov. 1916, 5849, June, 1917, 6552; Cambalache, March 28, 1916, 5089; Quebradillas, Dec., 1916, 5849; Arecibo, Jan. 1917, 6210. Common everywhere. (Pl. XXV, fig. 1; pl. XXXI, figs. 5, 6.)

BROWN LEAF SPOT. (*Cercospora longipes.*)

This is one of the rarer leaf spots in Porto Rico and is of interest chiefly because of the fact that, although of no importance here, it is considered in British India as a very serious source of loss. It again serves to illustrate how the various fungi vary in their severity in the different cane regions.

The spots produced by this fungus are quite typical although they may be at times confused with those due to *Helminthosporium*. They are elongate oval in shape, with a definite margin, a deep brown in color, appearing the same on both sides of the leaf, averaging one

centimeter long by four to six millimeters wide. Spots due to *Helminthosporium* are generally larger, more irregular, and more numerous. The spots rarely coalesce as mentioned by Butler, nor does the leaf appear to die prematurely. Spores are produced on the under surface, and are typical. A second conidial (pycnidia) stage described by Butler has not been found in Porto Rico. It has been collected on two varieties only, Otaheite and P. R. 217. Other than from Porto Rico this disease has been reported only from British India by Butler (10).

CERCOSPORA LONGIPES Butler.

Elongate spots on both sides of the leaf, often confluent, at first red, drying to a straw color with a brown ring; hyphae collected in gregarious heads, and generally on the under surface of the leaf, flexuous, brown, above geniculate or denticulate, 100–20 X 4 mu., conidia obclavate, tapering upward, straight or curved, 4–6 septate, 40–80 X 5 mu. Description after Butler.

PORTO RICO.—On living cane leaves, Río Piedras, Feb. 10, 1914, 1641, March, 1917, 6315. Not common. (Pl. XXXI, fig. 11, 12.) Original determination by J. A. S.

RED STRIPE OF THE LEAF.

This disease is characterized by a reddening of the midrib, which may vary in length from a mere spot to almost the entire length of the blade. The stripes may be continuous or as is a very marked characteristic at times may occur in sections of varying length with apparently normal areas between. In advanced stages the center of the stripes on the upper surface becomes a dull brown and fruiting pustules will be found. (Pl. XXV, fig. 6.)

The injury due to this disease is neglible under Porto Rican conditions, but Edgerton (25) has demonstrated that in Louisiana the red stripe characteristically gives *Colletotrichum falcatum* when cultured, and may be taken as an early symptom of infection of the plant by this fungus. Stevens of Florida corroborated Edgerton's findings. For this reason some studies have been conducted to ascertain the significance of red stripe in Porto Rico.

These have been carried out by isolations from red stripe specimens, by inoculations, and re-isolations. A number of different fungi have been encountered in the course of this work, mostly forms of *Colletotrichum*.

In a series of isolations commenced October 1, 1912, four of nine tubes yielded a form called *Colletotrichum* C and one tube *Colletotrichum* A. Those remaining were discarded because of contamina-

tions. The two fungi obtained remained true to type in cultures. October 22 a second series was commenced from which *Colletotrichum* C was obtained from ten tubes, *Colletotrichum* B from two, and *Melanconium saccharinum* from one. Further cultures were made in December, from which form C only was obtained. No inoculation tests were made at this time.

In 1916–17 further tests were made of the red-stripe disease. In the first series of inoculations[1] using a culture of *Colletotrichum falcatum* isolated from a diseased stalk, typical striping resulted in all cases (ten) and but one of ten checks showed any signs of infection. A second series of twenty-nine inoculations gave the same result, two out of nine checks also showing striping. All inoculations were made with a hypodermic needle. The cane showed some red striping other than the inoculations, explaining the two checks diseased.

A third series of puncture inoculations of the midrib was made using pure cultures of *Melanconium sacchari*, *Thielaviopsis paradoxa*, *Cytospora sacchari*, *Sclerotium Rolfsii*, and *Trichoderma lignorum*. With the exception of the latter all produced red striping, varying somewhat in the shade of red, but otherwise characteristic of the disease. *Sclerorotium* stripes were of a decided orange-red color.

A similar series, using *Melanconium*, *Colletotrichum* C, *Colletotrichum falcatum*, *Cercospora vaginae*, *Cytospora*, *Thielaviopsis*, and *Sclerotium*, gave similar results. There was considerable variation in color, the two *Colletotrichums* giving the typical color. *Melanconium* and *Thielaviopsis* gave doubtful results. It was possible to reisolate a majority of the fungi used.

A further series of laboratory damp-chamber tests, short externally sterilized sections of reddened mid-ribs being used, gave *C. falcatum* four times, *Colletotrichum* C. once, and an ascomycete (undet.) once.

It is apparent from these studies that more than one form is concerned in the red stripe disease, although *Colletotrichum falcatum* and related forms are most abundant. A wide range of fungi when introduced into a wound are capable of producing red stripes. Red striping is common where a leaf has been injured, but is also equally common where there are no signs of injury. Certain forms commonly found in this connection are here tentatively described.

COLLETOTRICHUM A.

Typically small hyaline, slightly falcate spores, forming a cottony white growth on potato cylinders, which become somewhat bluish in

[1] Inoculations made by R. C. Rose, assistant patholegist.

the lower part; spore masses inconspicuous, pink; no setae known; spores varying in shape from cylindrical to falcate; in size from 3.4–10.2 mu. or to 25.5 mu. in length, or 5.2 to 22.1: from 1-celled to 3-celled. (Plate XXVIII, fig. 15.)

This variation in septation naturally throws this fungus out of the genus *Colletotrichum* but as its manner of growth and spore formation is typical of *Colletotrichum* it is here considered in this group.

Colletotrichum b.

Mycelial growth in cultures scanty, white, cottony, spore masses conspicous, pink; spores cylindrical, rounded at both ends, 3.4–5.1 X 13.6–14.4 mu., spore formation typical of the genus, setae not seen. (Pl. XXVIII, fig. 18–20.

Colletotrichum c.

Found on the cane in the field as well as on cane in damp chambers; profuse cottony white growth in cultures; minute slightly pinkish spore masses arising from tiny black spots on midrib or blade of leaf; setae absent or commonly present, straight or flexuose, averaging 80 mu. long; spores thick, falcate, averaging 6.8 X 17 mu. (Pl. XXVIII, fig. 10–12.)

The above data combined with the fact that red rot has never been found in connection with red striping at any stage of growth renders the latter worthluess as a means of diagnosis of the former disease in Porto Rico.

WITHERTIP.

This disease is, as its name indicates, characterized by a withering of the tip of a green leaf or the margin of the leaf. The affected portion becomes brown and dead, and on it appears one or more fungi. *Hormiactella* is common in such cases. In addition, the form of *Colletotrichum* described above as *Colletotrichum C*, is common: as well as *Periconia sacchari*, and *Sphaerella sacchari*.

Under ordinary conditions these fungi may be found on almost any withered leaf. In 1913, a case was noted at Naguabo in which D–625 was severely affected by wither tip at about eight months of age, a very unusual circumstance, but other than these fungi nothing could be found to account for the condition. The plants were all well rooted, were not unusually affected by insects, and seemed to be green healthy plants excepting for the tips of the leaves.

Cobb (15) described a similar disease from Hawaii and figured setae and spores which correspond to those of *Hormiactella*, but without suggesting a name.

THE PINEAPPLE FUNGUS (*Thielaviopsis paradoxa.*)

The injury caused by this fungus is restricted to the cane cuttings. An affected cutting is usually killed either before any shoots are produced or before the new shoots can establish themselves on their own roots. The loss due to this disease varies considerably, depending upon the variety of cane, moisture condition of the soil, and possibly other factors. As will be noted in more detail later not all seed which fail to germinate have been invaded by this fungus, but it is responsible for the death of a large proportion. Out of one lot of dead seed examined, twenty-five per cent showed this disease and of another lot but ten per cent. The loss in some instances, however, must be much higher. Of healthy seed growing under normal conditions a negligible per cent will be attacked. The disease makes great headway whenever conditions for prompt germination are lacking, and becomes especially severe if the seed has been left in piles or sacks for some time after cutting. For this reason all seed that is to be shipped or which it is not possible to plant at once should be treated.

It is difficult to obtain satisfactory data as to the resistance of the various varieties of cane from field observations alone because of the fact that other fungi are so often involved in the death of seed pieces. To overcome this difficulty seed of a considerable number of varieties was obtained and inoculated with *Thielaviopsis.* After these cuttings had been planted a definite time they were dug up and careful measurements of the amount of infection were taken. The results are given in the following table and it will be noted that there is a very decided varietal difference in susceptibility.

Variety	No. seed planted	Total No. joints	No. joints infected	No. seed infected	% injury
B. 306	20	61	9	9	15
Cavengerie	11	19	12	8	20
D. 109	20	58	17	11	30
Sealy Seedling	17	19	21	12	40
D. 625	18	62	23	13	40
Otaheite	17	52	23	13	40
B. 3289	21	19	27	16	45
T. 77	18	55	21	17	60
B. 1753	18	17	37	15	65
D. 116	18	60	39	18	65
B. 109	19	59	35	18	65
Cristalina	21	72	54	17	70
D. 117	18	56	38	17	70
B. 3696	19	65	38	17	70
B. 1355	16	56	53	15	80
B. 376	15	54	10	14	80
B. 1596	11	56	13	11	85
B. 3708	11	36	31	13	85
B. 1376	18	19	43	16	90
B. 1356	16	63	60	16	90

Thielaviopsis is a much more serious trouble of pineapples than of cane. It is the cause of practically all of the soft rot or shipping rot as well as a base rot of slips, and spotting of the leaves. The loss from the rot is exceedingly heavy, five to ten per cent of a shipment being not uncommon, and cases are known which ran as high as seventy-five per cent. The fungus has been also reported by Fawcett of the Mayagüez Station as causing a "stem-bleeding of coconuts.

Sufficient inoculations have been made to demonstrate that but one form is involved in the attacks on the various hosts.

A number of experiments have been carried out in seed treatment (51). It was found that when the seed was planted under good conditions no perceptible improvement in germination resulted between treated and untreated lots. When disinfectants were applied to infected seed or to good seed planted under poor conditions, there was considerable improvement. As a consequence of these results, which are in accord with those of other workers, treatment is recommended only where the seed can not be planted at once, or where for some reason conditions are not favorable. Bordeaux mixture is the only practical material now in use for this purpose.

Occurrence in other countries.—This disease was reported by Gough (36) in 1911 from Trinidad, and by Edgerton (24) from Louisiana as rare. Of Hawaiian conditions Cobb (14) says "according to my observations the pineapple fungus causes the decay of more cane cuttings in Hawaii than any other one cause. The expense of replanting is largely due to the loss of cuttings through this rot." Butler (10) states that in British India he had found it on three occasions only, all being on recently imported seed from Java and Mauritius. It is of considerable importance in Java where it has been studied by Went (95, 96.) The disease also occurs throughout the British West Indies, (18, 64, 70, 71), particularly in Barbados.

Description.—The presence of the fungus can be readily noted by the characteristic blackened sooty area running through the center (Pl. XIX, fig. 3,) of the stalk. There is also a very distinct odor of pineapples present, hence the common name of the disease. There has been much confusion in the literature between *Thielaviopsis* and *Melanconium*, the macro and micronidia of the former having been considered as further stages in the life cycle of the rind disease.

THIELAVIOPSIS PARADOXA (De Seynes) J. Hohn.

Sterile hyphae hyaline, or pale fuscous, septate. Fertile hyphae septate, not branched. Macroconidia ovate, fuscous, catenulate, at length separating ,thick walled, usually vacuolate, 16–19 X 10–12

mu. Microconidia cylindric, hyaline, thin walled, catenulate, produced within the hyphae and issuing through the ruptured apex, 10–15 X 3.5–5mu. Microconidiophores 100–200 mu., swollen toward the base. Description after Went and Larson.

PORTO RICO.—From cane cuttings, Yabucoa, March, 1911, 4041; Río Piedras, March, 1912, 4566. June, 1915, 2779. Common everywhere. Also occurs on coconut, and pineapples. (Pl. XIX, fig. 3; pl. XXIX, fig. 8–10.)

OTHER FUNGI ATTACKING CANE CUTTINGS.

As has been already noted *Thicaviopsis* is not alone responsible for the death of seed or their failure to germinate. A considerable number of other fungi are commonly found in this connection, as would be expected from the position and unprotected condition of a cutting, presenting ideal conditions for fungus growth. All of these will be greatly favored by conditions which make germination slow or difficult, too deep planting in wet soils, and shallow planting in dry porous soils or in times of drouth.

Melanconium sacchari is one of the important fungi found in this connection. In its initial stages it is more difficult to discover than *Thielaviopsis*, a fact which presents a serious obstacle to seed selection. In one instance of a quantity of seed which had been sacked for some time and finally discarded, 110 seed were infected with *Melanconium sacchari*, 67 with *M. saccharinum* and 289 were still sound apparently. Two weeks later, of this latter lot, 135 were infected with *M. sacchari*, 91 with *M. saccharinum*, and 8 with *Thielaviopsis*.

In another experiment, conducted primarily for other reasons, the following fungi were encountered on dead seed pieces, not necessarily the primary cause of death but contributing factors: *Melanconium sacchari*, *Schizophyllum commune*, *Sclerotium Rolfsii*, *Trichoderma lignorum*, *Diplodia cacaoicola*, *Monilia sitophila*, and *Thielaviopsis*. The effect of an unexpected period of dry weather was especially noted as a primary cause of death. Seed inoculated with *Colletotrichum falcatum* suffered severely, some varieties losing as high as thirty-five per cent.

MINOR FUNGI AND DISEASES.

Of the various fungi here-in-after considered very few can in any sense be considered as causes of disease. Some act as wound parasites or in some instances have been found apparently as true parasites, but all are of relatively minor importance.

It has been found difficult, if not impossible, to draw a line between those of economic importance and the others, so that all forms found are included. Such a procedure will be of value since some of these fungi may at some time assume a parasitic role or they may be those reported as causes of disease in other cane growing regions.

All are grouped in this one division since it would be rather difficult to assign them to the other sections satisfactorily, growing as they do to a large extent on cane trash or débris, including leaves. stalks, roots and cuttings. Descriptions are given where the original has been modified or changed and of such species as are recorded as new.

ARCYRIA CINEREA (Bull) Schum.

PORTO RICO.—On dead leaves, Río Piedras, Jan., 1914, 1169, Nov., 1916, 5806. Also common on dead wood. Determination by Dr. W. C. Sturgis. (Pl. XXV, fig 5.)

A gray, stalked form with cylindrical to elliptical heads, resembling the following species except in color.

ARCYRIA DENUDATA Fr.

PORTO RICO.—On dead leaves, Río Piedras, Jan., 1914, 1170, 1915. 3379. A delicate, red, stalked form common on dead wood everywhere. Determination by Mrs. F. W. Patterson.

CRATERIUM AUREUM (Shüm) Rost.

PORTO RICO.—On cane trash. Mercedita, Jan., 1912, 4167; Río Piedras, Oct., 1915, 3167, Nov., 1916, 5801. Original determination by Dr. Sturgis. A small stalked form globular to ovoid.

CRATERIUM LEUCOCEPHALUM (Pers) Rost.

PORTO RICO.—On cane trash. Río Piedras, July, 1916, 5642. Not common. Determination by Dr. Sturgis.

DICTYDIUM CANCELLATUM (Batsch) Macbr.

PORTO RICO.—On cane trash, Oct. 1915, Río Piedras, 3172. Rare. Determination by Dr. Sturgis.

FULIGO SEPTICA (L) Gmel.

Fuligo ovata (Schaeff) Macbr.

PORTO RICO.—On cane trash, Río Piedras, April, 1912, 4314. July, 1912, 4492; Juana Díaz, March, 1915, 2645. (Comm. *Wolcott*). Common on plant debris of all kinds. Determination by Dr. Sturgis.

Lycogala epidendrum (L) Fr.

Porto Rico.—On dead cane stalk, Río Piedras, Feb., 1914, 1319. Also collected on dead bamboo sections and dead wood. Globose. ashen-colored, sessile fruiting bodies, resembling small puff-balls, .5–1 cm. diameter. (Pl. XXIII, fig. 5.)

Physarum cinereum (Batsch) Pers.

Porto Rico.—On living leaves, Manatí, *Wolcott*, Feb., 1915, 2592. Also collected on living leaves of *Phaseolus vulgaris*. *Lactuca Sativa*, and several common weeds. Determination by Dr. Sturgis.

Physarum compressum Alb. & Schw.

Porto Rico.—On dead leaves, Cortada, Jan., 1912, 4166. Rare Determination by Dr. Sturgis.

Physarum nodulosum (Cooke et Balf.) Mass.

Porto Rico.—On green leaf-sheaths of cane, Río Piedras, Jan., 1914, 1177. Determination by Mr. F. W. Patterson.

Stemonitis fusca Roth.

Porto Rico.—On cane trash, Río Piedras, Nov., 1915, 4115. Determination by Mrs. F. W. Patterson.

Stemonitis splendens Rost.

Porto Rico.—On cane trash, Río Piedras, Sept., 1912, 4618, Feb., 1915, 2574. Also common on rotten wood. Original determination by Dr. Sturgis.

Eurotium argentinum Speg.

Porto Rico.—On dead cane leaves and stalks, Río Piedras, Nov., 1915, 3245. Observed especially on herbarium specimens. It forms very numerous, minute, yellow, globular fruiting bodies. An *Aspergillis* sp. with dull gray heads occurs in connection with the *Eurotium*.

Chromocrea gelatinosa (Tode) Seaver.

Porto Rico.—On dead and dying leaf-sheaths of sugar cane, Río Piedras, Jan., 1913, 4751, Jan., 1914, 1171, Feb., 1914, 1409, Feb., 1917, 6380. (Pl. XXVII, fig. 8–10.)

This species produces fleshy, bright yellow stromata on the leaf-sheaths, becoming much darker with age.

Chromocreopsis striispora Stevenson sp. nov.

Stromata scattered, tubercular, subglobular to flattened, constricted at the base, often substipitate, 1–3 mm. dia., less in height, brick red at first, duller in dried specimens, with the black necks of the perithecia protruding; asci cylindric; spores uniseriate, dark brown, elliptic-ovoid, ends rounded, 1-guttulate, 20–22 X 5–7 mu., striate, striations showing best when spores are partially mature.

PORTO RICO.—On dead cane stalk, Gurabo, July, 1915, 2026 (type). Rare. This species is characterized by the shape and striations of the spores. It was first examined by Dr. F. J. Seaver, who suggested the name.

GIBBERELLA PULICARIS (Fries) Sacc.

PORTO RICO.—On dead cane, Río Piedras, April, 1911, 4053, Jan., 1912, 4169, Sept., 1912, 4586, Jan., 1914, 1179; Las Monjas, April, 1911, 4048. Also collected on *Panicum barbinode* and *Eriochloa subglabra*. (Pl. XXVII, fig. 14–15; pl. XXIII, fig. 2.)

The minute, ovoid perithecia of this species are superficial, generally seated on a stroma, black to the unaided eye, but blue with transmitted light.

HYPOCREA RUFA (Pers) Fries.

PORTO RICO.—On dead cane stalks, Río Piedras, Jan., 1914, 1199, Feb., 1914, 1322, 1345. Also collected on dead wood. (Pl. XXIII, fig. 1; pl. XVII, fig. 1–2.)

The stromata of this species are subhemispheric, irregular at times, 2 mm. to 1 cm. in diameter, brick red, darker with age, and roughened by the necks of the perithecia.

NECTRIA FLAVOCILIATA Seaver.

PORTO RICO.—On dead cane stalks, Río Piedras, Jan., 1914, 1213, Feb., 1914, 1333, 1346. Also collected on dead wood. The less common of the Nectrias. Characterized by a covering of sulphur-yellow hairs. (Pl. XXVII, fig. 16–18.)

NECTRIA LAURENTIANA Marshal.

With stromata somewhat broad, convex, superficial, 1–2 mm. dia., seated on a hyaline web, delicate and evanescent; parenchyma white: perithecia densely caespitose, globose, 250–350 mu. diam., strongly rugose to subsquamulose, ferruginous: asci 8-spored, oblong-cylindrical, attenuate-truncate, finally obtuse, subsessile , 60–70 X 7–8 mu., aparaphysate; spores uniseriate, equilateral, 1-septate, constricted at

the septa, 12–13.5 X 4.5–5 mu., at first strongly granulose, epispore rarely subasperulate. Translation of the original.

PORTO RICO.—On dead and dying cane stalks, April, 1911, 4012, 4047, 4067, Jan., 1914, 1644, 1915, 5164, March, 1916, 5102, July, 1916, 5637; Loíza, June, 1916, 5591. Common. Further study will probably prove it distinct from N. *Laurentiana,* an African form. (Pl. XXVII, fig. 21–23.)

This is a very common fungus on canes primarily injured by borer or other causes, producing a white dry rot.

VALSARIA SUBTROPICA Speg.

PORTO RICO.—On rotting cane stalks, Río Piedras, Jan. 1914, 1175. Determination by Mrs. F. W. Patterson. The perithecia are erumpent, scattered or aggregate, black, subglobose, carbonaceous, ostiolate. (Pl. XXI, fig. 3; pl. XXVII, fig. 24–26.)

PHYSALOSPORA TUCAMANENSIS Speg.

PORTO RICO.—On dead cane stalk, Carolina, Jan., 1915, 2520. Rare. Determined by Dr. Seaver. This fungus was originally described from Argentina by Spegazzinia (73) on cane leaves, particularly the sheaths. The perithecia are minute, black and emersed in the substratum.

ROSELLINIA PARAGUAYENSIS Stark.

PORTO RICO.—On rotting cane stalk, Río Piedras, Jan., 1914, 1179. Determination by Mrs. F. W. Patterson. (Pl. XXXI, fig. 16–18.) The black gregarious perithecia are immersed, then erumpent, and are clothed with a black tomentose subicle.

ROSELLINIA PULVERACEA (Ehrh) Fuch.

PORTO RICO.—On dead cane stalk, Río Piedras, Dec., 1916, 5853. Determination by Dr. F. J. Seaver.

The perithecia are crowded, often aggregate crust-like, superficial, globular, very minutely tuberculate, smooth, ostiolate.

SPHAERELLA SACCHARI Speg.

Spots none, or indeterminate; perithecia hypophyllous, densely crowded in series, globose, 130–180 mu., smooth, immersed, ostiole scarcely perforating the epidermis, not exserted, membranous coriaceous, subopaque, dark olive. Asci cylindric, 70 X 12 mu., upper end obtuse, lower end, slightly attenuate, abruptly and minuately nodu-

lose-pedicellate, aparaphysate; spores ellipsoid, 16–20 X 5–6 mu., 1-septate, scarcely constricted, hyaline, smooth. Description after Spegazzinia.

Porto Rico.—Common on dead cane leaves, often in connection with *Periconia sacchari*, as the apparent cause of wither-tip or dying of leaves, Fajardo, Dec., 1914, 2536. Commonly observed in all parts of the Island. First described by Spegazzinia (73.)

Xylaria apiculata Cooke.

Clubs black, stipitate, simple, .5–1 cm. long, apiculate, rarely obtuse; surface with fine raised lines; stipe black, filiform, about 1 mm. thick, smooth, varying much as to length, .5 to 4 cm.; perithecia prominent, papillate; asci cylindrical; spores uniseriate, mostly 6 X 12–14, rarely up to 24 mu. long, when young with a large gutta, when old with an indistinct septum. Description after Lloyd, Myc. Notes 48: 675.

Porto Rico.—On dead cane stalks, Río Piedras, Dec., 1913, 1109, Oct., 1915, 3216, July 1917, 6603. Very common on dead wood everywhere.

Lachnea cubensis (B&C) Sacc.

Porto Rico.—On dead cane leaves, Río Piedras, 1914, 1288. Determination by Dr. F. J. Seaver.

The cups are small, concave, and red with brown marginal setae.

Guepinia palmiceps Berk.

Porto Rico.—On dead cane stalk, Río Piedras, Feb., 1912, 4288. Determination by Dr. Burt.

Differs from *G. spathulata* macroscopically in the yellow-red tips.

Guepinia spathulata Jung.

Porto Rico.—On dead cane stalks, Río Piedras, Feb., 1914, 1330. Common everywhere on rotten wood. Determination by Prof. Lloyd. Producing cartilaginous spatulate, erect, yellow hymenophores, 1–3 cm. tall.

Asterostroma cervicolor (B & C) Mass.

Asterostroma albido-carneum (Schwein) Mass.

Porto Rico.—On dead leaf-sheaths at base of living cane stalks, and on soil and cane trash surrounding them, Río Piedras, Dec., 1911, 4109, Sept., 1912, 4632, June, 1917, 6557. Determination by Dr. Burt. (Pl. XXVI, fig. 4–7.)

Forming a thin white layer over the substratum, microscopically characterized by 3–4 armed stellate appendages on the hyphae.

PENIOPHORA CINEREA (Fr.) Cke.

PORTO RICO.—On dead cane stalk, Río Piedras, July, 1916, 5638. Determination by Dr. Burt. A very common form on dead wood, particularly on dead branches of citrus, forming cinereous fruiting patches.

PENIOPHORA FLAVIDO-ALBA Cooke.

PORTO RICO.—On dead cane stalks, Río Piedras, Dec., 1916, 6068. Determination by Dr. Burt. Common on dead wood.

TREMELLODENDRON SIMPLEX Burt, Ann. Mo. Bot. Garden 2:742. 1915.

Fructifications about 2 cm. long, 2 mm. thick, scattered, erect or suberect, drying hard, brittle somewhat longitudinally wrinkled and sometimes compressed, black above, olive-ocher with the hymenium towards the base; hymenium amphigenous on the lower half of the fructification, olive-ocher, hyaline under the microscope, with the surface consisting of colorless clavate paraphyses 5 mu. thick, and with basidia and spores at base of the paraphyses; basidia longitudinally septate: 11 X 7 mu.; spores hyaline, even 7.5–9 X 5–6 mu. Description after Dr. Burt.

PORTO RICO.—On cane trash, Río Piedras, 1911. Rare.

HYDNUM SACCHARI (?) Spreng.

PORTO RICO.—On dead cane, Río Piedras, Jan., 1914, 1174. Determination by Mrs. F. W. Patterson.

ODONTIA SACCHARI Burt Ann. Mo. Bot. Garden 4, No. 3. 1917.

Fructification resupinate, effused, portions may be peeled from substratum when moistened, floccose, white, becoming ivory-yellow to pale olive buff with age or in the herbarium, not cracked, the margin thinning out, floccose-reticulate under a lens; granules minute, crowded, about 8 to a mm.; in structure 100–300 mu. thick with the granules extending 15–45 mu. more, composed of suberect, branched, loosely interwoven hyaline hyphae 3.5–4 mu. in diam., occasionally nodose-septate, not incrusted, bearing singly along their sides in their middle region hyaline, cylindric, even spores 9–11 X 3–4 mu.; basidia simple, 2 sterigmata: basidiospores hyaline, even, subglobose, 3.75 X 3–3.75 mu.; cystidia septate, cylindric, more or less granular incrusted, hyaline, 6–9 mu. in diam., protruding 20–60 mu., about 1–3 to a granule at the apex. Description Dr. Burt's.

PORTO RICO.—On dead leaf-sheaths at the base of living cane stalks and on dead cane stalks, Río Piedras, July, 1912, 4509, July, 1915, 2908, July, 1916, 5628, April, 1917, 6382. Determination by Dr. Burt. Pl. XXVI, fig. 11, 12.)

This same form has been referred to by Horne in Cuba as *Peniophora* sp. and later as probably *Hypochnus sacchari* Speg. (38,39). The latter has also been suggested as the proper designation for the Porto Rican fungus, but Spegazzinia's (73) description of the *Hypochnus* as the cause of a disease of the bud (*cogollo*) of the stalk rather effectively disposes of this possibility to say nothing of the characteristics of the fungus itself. This form is quite clearly a saprophyte only, although at times occurring as does *O. saccharicola*, the more common species, at the base of living cane stalks.

MERULIUS BYSSOIDEUS Burt sp. nov.[1]

PORTO RICO.—On dead cane and soil, Río Piedras, Aug., 1912, 4664. Forming a thin layer on rotten cane trash and soil.

POLYPORUS OCCIDENTALIS Klotzsch.

Coriolopsis occidentalis (Klotzsch) Murrill.

PORTO RICO.—On dead cane stalk, Río Piedras, Dec., 1913, 1212. Very common on dead wood every-where. (Pl. XXI, fig. 2.)

POLYSTICTUS SANGUINEUS L.

Pycnoporus sanguineus (L.) Murrill.

PORTO RICO.—On dead cane stalks, Río Piedras, Jan., 1914, 1181, Feb., 1914, 1294. Very common everywhere, particularly on dead wood. A striking form because of the bright red color of the pileus.

POLYSTICTUS SINUOSUS (Fr.) Sacc.

Color from white to yellowish, mostly resupinate; pores broad, flexuous daedaloid; spores hyaline, cylindric-curved, 5–6 X 1–1.3 mu.; basidia clavate 15–16 X 4–5 mu.; hyphae of context tubular, 2.5–3.5 mu. diam. Description after Saccardo.

PORTO RICO.—On dead cane stalks, Río Piedras, Feb., 1914, 1291, Feb., 1917, 6206; Juncos, July, 1915, 2905. Determination by C. G. Lloyd. Myc. Notes No. 45. (Pl. XXII, fig. 3.)

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[1] To be described by Dr. Burt in Ann. Mo. Bot. Garden IV, No. 4, Nov. 1917.

TRAMETES NIVOSA (Berk) Murrill.

PORTO RICO.—On dead cane stalks, Río Piedras, Dec., 1913, 1211, Oct., 1914, 2277, Dec., 1914, 2672, Dec., 1916, 5859. Determination by Prof. Lloyd. A common white form, sporophores often sessile and somewhat abnormally shaped.

LENTINUS CRINITUS (L) Fr.

PORTO RICO.—On dead cane stalks, Río Piedras, Feb., 1914, 1295, Jan., 1914, 1198, Feb., 1916, 6113. Common everywhere on dead wood. Sporophores 4–7 cm. broad, pale-fawn colored to dark reddish brown, covered with stiff squamose hairs.

Marasmius borinquensis Stevenson sp. nov.

Pileus minute, delicate, single or gregarious, hemispheric, later expanding, subumbilicate, reaching 3 mm. broad, but commonly 1–2 mm. only: surface radiate-sulcate, glabrous, white, yellow on drying, membranous, margin involute, concolorous; lamellae few, usually about 10, occasionally forked, distant, white, yellow on drying, adnate: spores broad elliptic or ovoid with a small point at one end, 5.1 X 6.8 mn., hyaline; stipe filiform, concolorous with pileus, slightly villous at base, 2–6 mm. long. Near *Marasmius Marbleae* Murrill.

PORTO RICO.—On cane (Otaheite) Río Piedras, Sept. 10, 1912, 4604 (type) Rare. (Pl. XXVI, fig. 15–17.)

MARASMIUS HIORAMI Murrill.

PORTO RICO.—On cane leaf-sheaths, cane trash, Río Piedras, Sept., 20, 1912, 4600. Rare.

MARASMIUS SYNODICUS (Kze) Fries.

PORTO RICO.—On dead cane trash, Río Piedras, Jan., 1917, 6195. Also collected on dead leaves and stalks of other grasses. Common.

The sporophores of this species are gregarious, 6–10 mm. broad, white or pallid, and 1–2 cm. high, with adnate gills.

SCHIZOPHYLLUM COMMUNE Fries.

PORTO RICO.—On dead and dying cane stalks, Río Piedras, Feb., March, 1911, 4029, 4051, 4058, 4065: Plazuela, July, 1911, 4071. Commonly observed in all parts of the Island. Also very common on dead wood. (Pl. XXII, fig. 4.)

This is one of the commonest forms observed on dead and dying

cane stalks. In one case it was found on a stalk which was otherwise normal, and in many instances it has been noted acting as a wound parasite. It is quite usual to consider it as a cause of a dry rot of cane stalks. It has been reported in this connection from both Java and Brazil (100.)

SCYTINOTUS DISTANTIFOLIUS Murrill.

PORTO RICO.—On dead leaves, Río Piedras, Jan., 1914, 1197. On dead leaves of *Paspalum sp.*, Río Piedras, June, 1917, 6494. Determination by J. A. S.

A delicate, white, sessile form, 5–10 mm. broad.

LYCOPERDON ALBIDUM Cooke.

Sessile, globose, white, 8–12 mm. diam.; spores smooth, clay-colored, globose, 3 mu. diameter.

PORTO RICO.—On cane trash, Río Piedras, Oct., 1915, 3171; Cortada, Jan., 1912, 4168. Determined by Prof. Lloyd. These are the first collections other than the type.

LYCOPERDON PUSILLUM Fr.

PORTO RICO.—On cane trash, Río Piedras, Feb., 1915, 2576. Determined by Prof. Lloyd. Not common.

LYCOPERDON PYRIFORME Schaeff.

PORTO RICO.—In cane fields, Río Piedras, Jan., 1912, 4187, Apr., 1912, 4324; Plazuela, July, 1911, 4075. Very common.

CYATHUS POEPPIGII Tulasne.

PORTO RICO.—On dead cane stalks, Río Piedras, Nov., 1911, 4082. Common on dead wood. First determined by Prof. Lloyd. (Pl. XXIII, fig. 6.)

SPHAEROBOLUS STELLATUS Tod.

Outer peridium stellate-lacinate, lobes 5–8, averaging 1.5 mm. diam.; inner peridium covered by an orange-colored gelatinous envelope which at maturity swells and causes the single sporangiole to be forcibly ejected, spores hyaline, cylindrical-ovate 5.1 X 10.2 mu. Description modified.

PORTO RICO.—On rotten cane trash, Río Piedras, Jan., 1913, 4750. Also collected on rotten bamboo, leaf-mold, etc. (Pl. XXIII, fig. 4; pl. XXVI, fig. 1–3.)

Phyllosticta sacchari Speg.

Spots very numerous, with a tendency to occur near the midrib, often confluent, especially at the ends, long linear, occasionally oval, running out into long points, .5–2 cm. X 1–2 mm. at times much larger, red brown at first, then dull tan or brown at center with red, definite, not raised margin; pycnidia hypophyllous on older spots, few to many, uniformly scattered, immersed, membranous, sub-globular, 125–175 mu. diam., prominent ostiole, conidia hyaline to smoky, ovoid to cylindric, ends rounded, 12–16 mu. X 2.5–4 mu., one or two guttulate. Description from specimens.

Porto Rico.—On living cane leaves, Juncos, July, 1915, 2924; Río Piedras, March, 1917, 6278. (Pl. XXIV, fig. 4.)

In common with some of the other leaf spots, this form has not been worked out satisfactorily. It is probably not *P. sacchari* of Spegazzinia (73) but it has not been thought worth while to name it anew. If it should appear in some abundance hereafter warranting further studies, an attempt will be made to place it exactly. Our specimens differ from one determined by Miss Young from the Stevens' collection as *P. sacchari*. The fragment of this material seen was apparently *Leptosphaeria sacchari*.

Vermicularia graminicola West.

Porto Rico.—On dead cane stalk, Río Piedras, Feb., 1914, 1270. (Pl. XXVIII, fig. 6–8.)

This species is characterized by erumpent, spherical pycnidia, with long black erect setae. It differs very decidedly from *V. sacchari*, described recently by Averna-Sacca, (100) in that the latter possesses biciliate spores, and those of the present species are muticate.

Diplodia cacaoicola P. Henn.

Pycnidia scattered in the cortex of the host, innate, black; conidia ellipsoid oblong or sub-ovoid, 1-septate, obtuse at both ends, loculi 1-guttulate, black, 18–22 X 12–14 mu.

Porto Rico.—On dead cane stalks, Río Piedras, Jan., 1912, 4169, Feb., 1914, 1321, 1347, Oct., 1914, 2278, Oct., 1915, 3169, March, 1917, 6308; Vieques, Jan., 1917, 6194. Fairly common everywhere. (Pl. XXI, fig. 1; pl. XXXI, fig. 8–10.)

This fungus is most commonly found on dead seed pieces or rotten stalks, where the fruiting bodies appear as tiny black bodies buried in the tissues. In some instances, however, it is apparently able to act as a partial parasite, and to cause some loss. This action has

been observed in isolated canes, (generally insect injured stalks). of a number of varieties.

In the case of one variety only, D-625, has it been noted acting apparently alone. Other surrounding varieties in this instance remained normal, but of the D-625 fully twenty-five per cent of the stalks were attacked. The only external symtom was the withering and dying of attacked stalks from the top downward, in no way different from the death of a stalk from any one of many other causes.

Internally was found a very striking rot, which at once distinguished the disease from any other. The rotted areas extended from the top downward, rapidly covering the entire length of the stalk, and attacking the bundles first, which became red in color. The red coloration soon became uniform throughout the central pith region, bordered by an outer periphery of normal tissues. The attacked tissues were somewhat rubbery in consistency, lacking in juice, and rapidly turned brown on exposure to air. The rot finally worked through to the surface producing irregular brown patches on the internodes which finally coalesced. Canes after three months in the laboratory have not yet produced fruiting bodies. *Melanconium sacchari* was occasionally present as a secondary organism. The color of the rot was much deeper than that produced by *Colletotrichum*, the areas were more uniform, and the white patches characteristic of red rot were lacking. *Diplodia* was obtained in cultures.

This fungus, originally described from twigs of cacao, has been reported on cane by Butler (10) in British India and by Howard (41) in Barbados. The former described it as usually saprophytic only, but the latter found it at times parasitic and was able by inoculations to reproduce the disease said to be caused by it. Averna-Sacca (100) gives an account of a disease ascribed to *Lasiodiplodia theobromae*, which is doubtless the same species.

It is extremely doubtful if it will ever be of any real economic importance in Porto Rico, since it attacks only injured canes or weak varieties, D-625 being notoriously of such a nature.

MELANCONIUM SACCHARINUM(?) Penz. et Sacc.

Acervuli hypophyllous, gregarious, longitudinally seriate, oblong, 1 mm. long, by .5 wide, black, hysterioid erumpent; conidia large, globose compressed, 24 X 14 mu. black, smooth, borne on filiform, hyaline pedicels. Description after Saccardo.

PORTO RICO.—On cane leaves, Río Piedras, Dec., 1911, 4111, 4112, 4142, 4143, 4144, 4145, 4146, March 1912, 4294, June, 1917, 6559; Mercedita, Jan., 1912, 4171; Fajardo, March, 1912, 4291. On *Cym-*

bopogon citratus. Río Piedras. Oct., 1914, 2281. On *Bambusa vulgaris*, Trujillo Alto, Nov., 1914, 2396. Very common in all sections. First determination by Mrs. F. W. Patterson. (Pl. XXIV, fig. 2; pl. XXVIII, fig. 5.)

This fungus is extremely common on many varieties of cane, occurring on the back of the leaf-blades and sheaths and particularly on the back of the mid-rib It also occurs on the flower stalk. It does very little harm beyond hastening the death of leaves already weakened by other causes. The fungus is conspicuous because of the long lines of black immersed sporodochia opening by long slits, the black spore masses often being visible with a hand lens. Macroscopically it can not be distinguished from *Marsonia sp.*

Arthrobotrys superba Cda.

Porto Rico.—On dead and dying cane, Río Piedras. July, 1912, 4493. July 1917, 6607. First determination by Mrs. F. W. Patterson. (Pl. XXX, fig. 7–9.)

Aspergillus flavus Link.

Porto Rico.—A very common saprophytic form on dead cane, particularly on seed pieces in the ground, and on material after it is brought to the laboratory. A form morphologically not distinct attacks the mealy bug (*Pseudococcus sacchari*) of cane, often over wide areas. Also isolated from soil, moldy tobacco, and other sources.

Aspergillus niger Van Tieghem.

Porto Rico.—A common saprophytic form, particularly noted on imperfectly sterilized material in damp chambers. It produces a reddening of cane tissue.

Monilia sitophila (Mont) Sacc.

Effuse, beautiful deep rose in color, primary hyphae ascending from the procumbent mycelium, 120–130 X 12 mu., scantily septate-constricted, above divided into dichotomous branches; branches and branchlets somewhat broad, crowded, septate and easily separating: conidia acrogenous, shortly catenulate, globose, 10–12 mu., bases distinctly apiculate where joined by isthmi. Description after Saccardo.

Porto Rico.—On burnt cane, Río Piedras, March, 1911, 4042, 4057. Also observed at base of *Gynerium sagittatum* and *Sabal causiarum* where injured by fire. (Pl. XX, fig. 2.)

This very interesting fungus occurs on all debris remaining after

a cane field has been burned over, the very striking orange-pink clumps thickly clustered on every available bit of material over acres and acres make a most striking sight. Where the trash is not burned it very rarely occurs, and never more than as small scattered sporodochia at best. The fungus also causes a mold of bread much more serious than that due to *Aspergillus* or *Mucor*. In the laboratory it evinced a great ability to grow into other cultures and culture media through the cotton plugs and after one experience, during which considerable difficulty was had in getting rid of it, it has never been brought into the laboratory again.

TRICHODERMA LIGNORUM (Tode) Harz.

Forming more or less cottony, finally powdery sporodochia, subcircular to indefinite, up to 5 mm. diameter, white at first, then deep green with white margin; hyphae interwoven, subcompact, filiform, continuous, fertile hyphae erect, 2–4 lageniform branches or conidial bearing organs; conidia formed in globules of 8–10, spherical to elliptical, light green, 1.4–3 X 3–4.3 mu; heads averaging 7 mu. Description amended, after Saccardo.

PORTO RICO.—On dead and dying cane stalks and leaves, Aug., 1912, 4548, 4667, 4666, Jan., 1914, 1173, Jan., 1914, 1201, Oct., 1914, 2275, July, 1915, 2831, Sept., 1915, 3073, Apr., 1917, 6402, June, 1917, 6561. Very commonly observed in all parts of the Island. First determination by Mrs. F. W. Patterson. (Pl. XXI, fig. 4; pl. XXX, fig. 6, 10–12.)

This is an exceedingly common form in and about cane fields and has appeared a great number of times in damp chamber tests and in cultures. It is especially to be found on the lower leaf-sheaths, in connection with *Cerospora*, *Sclerotium*, and other fungi, at times apparently acting as a wound parasite aiding in the death of the leaf-sheaths. Because of the great frequency of its occurrence in the course of laboratory studies on the cane cankers of the mottling disease, internal rots of various types, etc., attempts were made to prove its parasitism, if any, by inoculations. Negative results were obtained, it not even being capable of producing red striping, hence it is now considered only as a saprophyte.

Arthrinium saccharicola Stevenson sp. nov.

Forming small black masses on the substratum, 1–1.5 mm. diam., not coalescing; sterile hyphae scanty, recumbent; fertile-hyphae simple, suberect to erect; aggregate, hyaline, with broad, black, numerous septae, swollen at base, about 100 mu. long; conidia sessile,

in a dense spiral about the sporophore, concave-convex when young, becoming doubly-convex, dark brown. 7.25 mu. diam. X 4.4 mu. thick.

PORTO RICO.—On dead cane leaves. Río Piedras. Feb., 1914. 1269 (type). (Pl. XXIX. fig. 1–3.)

BASISPORIUM GALLARUM Moll.

PORTO RICO.—On dead cane stalks and leaves, Río Piedras, Aug., 1912, 4545; Juncos, Aug., 1915, 2930. Determination by Miss Charles.

Observed on material from all parts of the Island. This is one of the very common saprophytic forms encountered in the work with cane fungi, it being found on all parts of dead and dying cane plants, often forming black irregular patches especially on leaves and dead seed pieces. It has turned up in cultures several times, in one instance of a top-rot case, and of various leaf-spots, but inoculations with it have not been successful. It also occurs on other grasses (*Panicum barbinode*, *Eriochloa subglabra*).

It is characterized by comparatively large black circular or disk-shaped spores, borne on jar-like basidia. The hyphae are hyaline to brown and scanty, and all that is commonly seen are great masses of the conidia.

CLADOSPORIUM HERBARUM (Pers) Link.

PORTO RICO.—On cane trash, Río Piedras, Jan., 1917, 6094, April, 1917, 6383. Very common on cane tops and trash lying in the fields after the cane is cut. Appearing as numerous, bright green, slightly raised masses uniformly distributed on the wilted leaves and discarded stalks over all fields, becoming dark green or black. Also common on other host material in many other situations.

Hormiactella sacchari Johnston sp. nov.

Sori small, black, scattered, about 1 mm. diam., consisting of sterile erect hyphae mixed with the fertile; sterile hyphae black, septate, more or less straight, 500–900 mu. long; fertile hyphae shorter, 200–300 mu. high, branching sparsely, bearing at intervals short lageniform branches or conidiophores; conidia in short irregular chains, spherical, rugulose, 6 mu. diameter.

PORTO RICO.—On dead cane leaves, Río Piedras, Feb., 1911, 4017, Dec., 1911, 4141, April 1912, 4313, May 1–12, 4353, 4357, August, 1912, 4538, 4567, Oct., 1912, 4638; Mercedita, Jan., 1912, 4153; Yauco, March, 1912, 4315; Canóvanas, July, 1915, 4525, Oct., 1912, 4642; Mameyes, Dec., 1912, 4711; Añasco, May 1916, 5350. Very common everywhere. Often associated with the wither-tip disease of the

leaves. More common on certain varieties. (Pl. XXX, fig. 1–5; pl. XXV, fig. 4)

Periconia sacchari Johnston sp. nov.

Fertile hyphae erect, scattered but very numerous, not blackening the substratum, dark 200–300 mu. high, with short branches at the tip; branches appressed, cylindrical, or more or less lageniform, sometimes constricted; conidia ovoid or elliptical to finally cylindrical in the mature form, rounded at both ends, brown, finally tuberculate, 11.2 X 22–24 mu.

PORTO RICO.—On dead and dying cane leaves, often associated with wither-tip. Río Piedras, April, 1917, 6384 (type). Very common. A common associate of *Sphaerella sacchari.* (Plate XXIX, fig. 16–18.)

Septonema sacchari Johnston & Stevenson sp. nov.

Forming small black fruiting patches on the substratum, sterile hyphae recumbent, often not apparent or anastomosing to form a loose net-work; fertile hyphae short but little different from the conidia; conidia catenulate, 1–3 septate, more often 2-septate, basal cell truncate, brown, lighter where the chains branch, minutely spiny, one end cell larger, rounded, and 7.25 X 13–25 mu.

PORTO RICO.—On cane leaves, Río Piedras, Feb., 1914, 1650, May, 1917, 6404 (type). Macroscopically resembles *Spegazzinia ornata.*

Tetracoccosporis sacchari Stevenson sp. nov.

Forming small, sooty, black, subcircular to irregular masses on the substratum,1–2 mm. average diam., occasionally coalescing to form masses up to 1 cm. diam.; sterile hyphae recumbent, generally not apparent; fertile hyphae erect, hyaline to smoky, strongly septate; septae appearing as broad black bands at short intervals; spores pleurogenous, sessile, completely covering conidiophore, arranged in regular series, more or less flattened-hemispherical, distinctly rugulose, cruciate-divided into 4 cells, averaging 10 mu. diam.

PORTO RICO.—On dead cane leaves, Río Piedras, Feb., 1914, 1421, Nov. 1916, 6049 (type). Macroscopically not distinguishable from *Spegazzinia ornata.* (Pl. XXVII, fig. 19, 20.)

TETRAPLOA ARISTATA (B & Br).

Plants scattered, few in number, generally among other fungi, olivaceous to black; conidia oblong, biseptate-muriform, brown to sooty, guttulate, 20–30 mu., apex formed by four horns, 60–90 X 4 mu., pluriseptate, lighter in color than body of spore. Description modified after Saccardo.

Porto Rico.—On dead cane stalks, Río Piedras, March, 1911, 4010. Very commonly observed when studying other forms, intermixed sparingly with them. (Pl. XXIX, fig. 11.)

Verticicladium graminicolum Johnston & Stevenson sp. nov.

Effuse, forming a uniform layer over the substratum, separating readily, dull brown to gray; sterile hyphae interwoven into a fairly compact net work, fertile hyphæ erect to reclining, brown, regular, verticillate branched, 3–4 branches at each node; branches cylindrical, short; spores eliptical to cylindrical, hyaline, 3–4 X 6.8–11 mu.

Porto Rico.—On cane leaves, Río Piedras, Sept., 1912, 4596, Feb., 1914, 1645 (type). (Pl. XXIX, fig. 14, 15.)

Graphium sacchari Speg.

Porto Rico.—On dead cane stalk, Río Piedras, March, 1911, 4010, Sept., 1912, 4621, Jan., 1914, 1180, Dec., 1916, 5858; Juncos, July 1915, 2925. Quite common. (Pl. XXXI, fig. 13–15.)

Myrothecium verrucaria (A&S) Dtm.

Porto Rico.—On dead and dying cane leaf-sheaths, Río Piedras, April, 1917, 6423. Sporodochia small, flat, dark purple to black with a white, villous margin.

Spegazzinia ornata Sacc.

Porto Rico.—On dead cane leaves, Río Piedras, Nov., 1911, 4079, Dec., 1911, 4108, April, 1912, 4311, 4318, July, 1912, 4490, Sept., 1915, 3072, June, 1917, 6551; Ponce, Jan., 1912, 4154; Sta. Isabel, Jan., 1912, 4164. Also collected on dead bamboo, pineapple leaves, and dead leaves of various weed grasses. Very common everywhere. First determination by Mrs. F. W. Patterson. (Pl. XXIX, fig. 6, 7; pl. XXIV, fig. 3.)

The sporodochia are jet black, flat, subhemispherical to irregular, and several mm. in diameter.

Tubercularia saccharicola Speg.

Porto Rico.—On dead cane stalks, Río Piedras, Aug., 1912, 4667, Jan., 1914, 1214, Feb., 1914, 1340; Carolina, Jan., 1915, 2522; Las Monjas, Apr., 1911, 4049. First determination by Mrs. F. W. Patterson. (Pl. XXIII, fig. 3; pl. XXVII, fig. 5–7.)

Undeterminate.

Botrytis sp.—On dead cane leaves, Río Piedras. 1914, 1422.

Capnodium sp.—On living cane leaves and stalks. Río Piedras. 1912, 4507, 4515. Spermatia and *Triposporium* stages.

Corticium sp.—On dead cane leaves. Río Piedras. 1195, 3224. A pink, sterile form.

Crepidotus sp.—On rotted cane stalks, Río Piedras, 1203, 1304.

Dasycypha sp.—On cane trash, Río Piedras. 2511.

Fusarium spp.—A number of species are commonly found on cane trash, material in damp chambers, in cultures of cane soils and in one instance as the apparent cause of a red-rot of cane stalks.

Lasiosphaeria sp.—On dead cane. Río Piedras. 1911, 4110.

Lophodermium sp.—On dead leaf-sheaths. Río Piedras. 1420.

Marasmius spp.—On cane trash a great variety of undeterminable species have been collected.

Marsonia sp.—On midribs of dead cane leaves, Río Piedras, 6416, 6429. Macroscopically not distinguishable from *Melanconium saccharinum*.

Odontia sp.—On dead cane stalk. Río Piedras, 1916, 6062. Distinct from the other species, but not yet named by Dr. Burt.

Peniophora sp.—On cane trash. Río Piedras. 1204. A yellow species, the only collection being sterile. (Pl. XXVI, fig. 13, 14.)

Polydesmus sp.—On dead cane leaves, Río Piedras, 1914. 1651. Macroscopically indistinguishable from *Speyazzinia* and *Tetracoccosporis*. (Pl. XXIX, fig. 13.)

Sclerotium sp.—On dead and dying cane leaves, particularly the leaf-sheaths, Río Piedras. April 1911, 4044, Aug., 1911, 4077, May, 1912, 4312, Oct., 1912, 4651, May, 1917, 6471. A gray form very distinct from *S. Rolfsii*.

Stilbum sp.—On dead cane stalks. Río Piedras, 1343, 1267. Not *S. incarnatum* reported on cane in Java.

Tapesia sp.—On dead cane stalks. Río Piedras. 1266. (Pl. XXVII, fig. 3, 4.)

Trogia sp.—On dead cane. Río Piedras, 1197. (Pl. XXVI, fig. 18, 19.)

Valsa sp.—On dead cane-stalks, Barceloneta, June 1917, 6435. The same species has also been encountered in cultures of leaf spots. It is not parasitic, as far as tests to date show.

Volutina sp.—On dead cane. Río Piedras, 1914. 1200. (Pl. XXVII fig. 11–13.)

CHLOROSIS.

Chlorosis of sugar-cane has been noted only in the southern and southwestern portions of the Island. the irrigated sections. It is found in varying degree of severity from cases with absolutely white leaves through various shades of yellow to those in which the affected leaves show only yellow stripes. Affected areas vary in size from a fraction of an acre to several hundred acres. It has been especially noted near Ponce, Yauco, and Santa Isabel.

Studies of the phenomenon from a chemical standpoint, have been conducted by Mr. P. C. Gile, (33, 34) of the Mayagüez Experiment Station. He made a soil survey of affected spots, analyses of the soils, and a series of experiments with manure and ferrous sulphate. He ascertained that bleached cane occurred where the soil was excessively calcareous, but that the real cause of the trouble lay in lack of sufficient assimilated iron. Plants treated with a solution of ferrous sulphate either when applied around the roots or painted on the leaves, regained a normal green color.

As a result, however, of the field experiments, the conclusion was reached that while increased yields and a measure of control were secured by applications of iron, the amount necessary made its use on a practical scale, prohibitive.

Field observations show the presence of fungi on chlorotic canes, but to the same extent as on normal cane, so that they have no direct relation with the disease, nor do insects. Earle (21) observed chlorosis near Ponce, confusing it with root disease with which it was associated. Chlorosis of sugar-cane has not been reported from other countries.

YELLOW STRIPE.

Yellow stripe is more or less of a chlorotic condition in which the chlorosis is restricted to stripes in the leaves. In Porto Rico this has never been seen in more than isolated stools of a field, with the exception of those cases where it occurs in connection with chlorosis on the south side of the Island.

In Java much has been made of this disease, but with no other conclusion than that it was a physiological condition, varying with the different varieties of cane.

MOTTLING.

About two years ago there was brought to the attention of the junior author a situation in the cane fields of the Arecibo-Aguadilla

district which was at that time already causing considerable loss. Since that time much attention has been given to the disease, several reports have been prepared[1] (75) and extensive field observations and laboratory studies are under way.

Since the initial observations were made the trouble has not only continued its ravages in the original territory, but has greatly enlarged its boundaries so as to include an area extending from near Bayamón to Añasco, or approximately a quarter of the Island. As to how long the disease had been present before the first report was recieved it has not been possible as yet to ascertain, but certainly a year, so that as near as is now known it has been active about three years. The disease is as yet confined to the upper reaches of the river valleys, to small inland valleys, and particularly to fields among the foot hills. The broad stretches of the coastal plain, but little above sea level, are still free of disease, although they are planted to the susceptible varieties of cane, and form great continuous areas. The rolling stretch of country between Arecibo and Aguadilla, a region which suffers much from drouth has been the most severely infected, and hundreds of acres have been abandoned to cane culture.

Losses.—The loss occasioned is very difficult to estimate since the diseased fields will show a variation of from one to a hundred per cent of infection. There appears to be a regular course followed by the disease. A few stools are infected the first year, scattered about the field. The second year infection becomes quite general and there is a decided falling off in yield. The third year the growth of the cane is so poor, and such stalks as are produced are so small, and lacking in juice that the crop is a total loss. The loss is still further increased by the fact that the Centrals refuse to receive any cane that shows evidence of the disease. There is no doubt but that the monetary loss already runs into the hundreds of thousands of dollars.

Name of the Disease.—Various names have been used for this disease. It is universally known among the planters as "La enfermedad—the disease," and it has been called "the new disease," the "mottling disease" and "cane canker." The mottling disease is the preferred term. Chlorosis is of course already in use for another trouble.

Symptoms.—The one marked and constant symptom of this disease, and the one by which it is easily recognized by any one who has

[1] Stevenson, John A.—La Enfermedad Nueva de la Caña. Circular 11, Insular Experiment Station. 1917.
In La Revista Azucarera, año 2, no. 24, p. 4–5, and no. 25, p. 5–6. 1917.
In El Mundo Azucarero, v. 5, no. 1, p. 19–24, fig. 10. Aug. 1917.
Cane Disease in Porto Rico. *In* La. Planter, v. 49, no. 5, p. 76–78. Aug. 4, 1917.

occasion to visit diseased elds. is the peculiar mottling of the leaves. In contrast to the uniform yellowing or whitening of the leaves characteristic of chlorosis. there occur innumerable white or at times yellowish spots and stripes with irregular, indefinite margins. In light cases the back ground may be practically normal green, but more often and especially after the first year the leaves are yellow green to yellow, interspersed with the white markings. It is not apparent that mottled leaves die any sooner, or are more subject to parasitic leaf fungi than normal leaves.

For some time there are no further symptoms than the mottling it being impossible to distinguish, except for this one point, diseased from normal stools. Mottled leaves do not die and fall any sooner than normal ones. nor do they cling abnormally to the stalk. The stalks are not stunted or visibly changed internally. It is quite possible to find stalks which show from one to ten or twelve lower leaves apparently normal, with all those above mottled. The mottling is apparent as soon as the leaves unfold. The reverse condition of normal leaves above, has not been observed. It is not certain yet as to whether a leaf which unfolds normally may become mottled later on. A varying number of stalks in a stool may show mottling, often only one, more often three or four out of a dozen.

The above represents conditions the first year of infection. The ratoon shoots from all infected stools, and from a varying proportion of those that were apparently normal, show mottling from the instant the new shoots are observable. Very seldom does this crop reach normal conditions of height and stand, more often around thirty to fifty per cent only.

At this stage in addition to the mottling another marked characteristic appears, a cankering of the stalks. These cankers or lesions appear first as far as observation show, before the leaf sheaths fall, but after they have become somewhat loosened, as linear spots, somewhat sunken, and brown in color. The soon become ashen or dull gray, and often coalesce to form continuous patches practically covering the internodes. They never, however, pass from one internode to another. They are superficial only, never penetrating for more than 1–2 mm., except along such cracks as occur. Even here the reddening that is found is seldom more than that usually found in such locations in normal cane.

The cracking or splitting is not considered a symptom, being merely a result of the drying up of the cane. Splitting normally occurs in many varieties. although of course it is more marked with this disease. There is no internal red-rot or other form of rot accom-

panying the cankers, but there is a shrinking of the internodes and a general condition of pithiness and lack of juice. All cankered canes show mottling of the leaves, but the reverse is not true.

It may be noted at this point that not only is there a lack of juice in cankered canes, but what does occur is of an objectionable nature from the mill stand point. A very high glucose ratio is reported (non-crystallizing sugars) and the juice behaves badly during clarifying and other processes to which it is subjected. A comprehensive series of chemical tests is about to be made at this Station, to be reported upon later.

Causes.—No definite cause has as yet been found although many have been suggested. The juice of diseased stalks has not been found to be infectious. No fungi have been found in connection with it which could reproduce the trouble. It has been found that apparently normal seed pieces from stalks showing mottling, even after disinfection and planting in sterile soil, produced mottled shoots.

The entire question of degeneration or running out of varieties, together with the effect of abnormal weather conditions and exceedingly poor agricultural practices have been studied as far as time and circumstances permitted, and are treated of more fully in other publications on this epidemic.

Varieties attacked.—Most of the cane of the infected district has been of two varieties, the striped or *rayada*, and the white (*blanca*) or Otaheite, probably the same as the old Bourbon cane. The white cane was first attacked and is at present most subject to the disease, the cankers being especially characteristic of this variety. Its elimination, as has already occurred in other parts of the Island, seems certain. The *rayada* during the present year has been in many places as badly attacked as the white, although there is still the possibility that strains from outside districts may remain immune.

Other varieties grown on a smaller scale and brought in for trial have been quite uniformly attacked, *bamboo, penang,* B–3412, B–208, yellow caledonia, *Cavengerie*, and others. A dark red variety, locally known as *sarangola* has been quite resistant but unfortunately is not a good milling cane, nor is it probable that it would have any great degree of resistance if planted on a large scale.

Comparison with other cane diseases.—This disease can not be confused with any of the stalk or leaf diseases described in the earlier part of this paper, the essential symptoms being sufficiently different. Moreover, in no instance has it been possible to find any more evidences of any of these than occur in normal fields. Rind disease has been especially watched for since it is the reputed cause of an

epidemic, that occurred in the British West Indies in 1893–7. It is very easy to find a great variety of fungi but none of them have as yet been capable of reproducing mottling.

The connection of root disease has been a more difficult problem, but it has finally become clear that root disease is not directly connected with the mottling. Either, may and does occur alone, and both are often found acting together, the cane suffering severely in any case.

The more the disease is studied the more it appears to resemble the mysterious "sereh" of Java. It is quite unlikely that it is that exact disease, but it is not improbable that it is of the same general nature, produced by the same or similar environmental factors. Many of the symptoms are the same, although none it must be admitted are those that are considered essential; for instance the course of the disease over three years, the stunting of stools and shortening of internodes (in advance cases), the fact that the disease is carried from old plants to new ones by cuttings, and a poor development of the root system. On the other hand this new disease in addition to the leaf mottling and stalk cankers not ascribed to "sereh," does not show gumming, internal red lines, more disease at the base of the stalk, or the abnormal stooling giving the grassy appearance from which the "sereh" takes its name.

Control.—Practically every conceivable measure which has ever been recommended for the control of cane diseases and especially those usually given as efficacious for root disease have been tried, and without any other result than the continued progress of the disease. Liming, increased cultivation, treatment with Bordeaux mixture, seed of established varieties brought from outside regions, seed of new varieties, and the use of land not before planted to cane, all these, and more have been tried.

It is apparent that very drastic measures will be necessary to check the epidemic. The foremost requirement will be the introduction of a rotation system, (a heretofore unknown practice in Porto Rican cane culture), and one which will include a legume. It is no easy matter to give a satisfactory outline for such a rotation, particularly the legume, and even after by such experimentation such is found, it is going to be equally or more difficult to get it adopted. In the meanwhile continued efforts are being made with new seedling varieties, particularly those produced at this Station, and it is hoped that some will ultimately be found which under proper care will succeed.

A complete account of the disease to date together with such

studies as have been made will occur in the forthcoming report of the Experiment Station, (1916–1917).

INJURIES DUE TO NATURAL AGENCIES.

In order to round out the subject of cane disease, it has been considered proper to include a consideration of injuries due to such physical phenomena or natural causes, as lightning, wind, drouth, and floods, often important sources of loss to the cane growers of the Island.

LIGHTNING.

Lightning injury to sugar-cane is apparently rare, but one instance having been observed (75). In this case all the cane, including the roots, in an area of approximately a square rod was killed, producing an open spot sharply set off from the surrounding normal cane. Nothing was left of the cane but charred remains of leaves and a few short pieces of stalk, some remaining erect. A growth of herbaceous weeds followed. No insects or fungi were present, even a considerable time after the cane was killed.

WIND.

Under normal conditions cane is quite resistant to direct injury from wind, although of course there is the indirect effect of the increased evaporation of the soil water supply, and checking of growth or even death when a shortage occurs.

The occasional hurricanes, however, often cause considerable losses depending somewhat upon the season in which they occur, or upon the age of the cane. With extreme wind velocities the cane may be uprooted over large areas, making practically a total loss, or young ratoons may be so wrenched and loosened as to give greatly decreased yields. Over the eastern end of the Island a decided falling off in estimated production was acredited to this cause in the season just ended.

Cane does not, however, suffer from wind to the extend that other crops, coffee and citrus, for example, do.

FLOODS, AND EXCESSIVE WATER SUPPLY.

Cane, a shall rooted crop is much subject to damage by floods. During the periodic overflows, characterizing the rivers of Porto Rico, much low land cane is washed out or the hold of the plants so weakened by the washing away of the soil that an effort must be put forth to recover, which must mean decreased yields. Cane is, however, the most resistent crop to this sort of condition.

It is generally considered that an excessive water supply, due to heavy soil or poor drainage, is very harmful. Such a condition is doubtless beneficial to the growth of many injurious fungi and there is a decrease in yield through loss of roots by disease or drowning (suffocation). Observations, made in connection with the mottling disease, have indicated that cane suffers more readily from a lack of water than from an over abundance.

DROUTH.

This is undoubtedly the most important of the various factors considered under the general heading. Large sections of the Island are so habitually dry that irrigation is absolutely necessary, and there are other important districts which suffer from periods of drouth of greater or less length at various seasons of the year. The influence of lack of sufficient water has been readily noted in those places where irrigation has been applied to some fields only. It often spells the difference between a crop and no crop.

One very important effect credited to lack of water is increase of root disease. There is undeniably an increase in the amount of fungus present, and it is not uncommon to find whole fields of stunted, yellow cane, apparently ruined by root disease. The exact relation of drouth and the fungi found in connection with the roots and the stalks of the cane is debatable.

It seems altogether probable that the most trying situation for cane is a succession of excessive rains and long drouths, a state of affairs often existing over large sections of Porto Rico.

ABNORMALITIES.

In Java the various abnormalities of the cane plant have been considered at great length (53). Many of the types reported for that Island occur in Porto Rico, but in isolated cases so that no significance is attached to them in the pathological work.

Canes are quite commonly found with buds or eyes missing from some of the nodes, or sometimes with two or more eyes at a node. Germination of the eyes in situ often with the production of lengthy shoots is common, being quite characteristic of certain varieties. It also occurs at times in connection with stalk-borer or other injuries.

There have occurred types of growth resembling those described for "sereh," the short grass-like habit for instance, and the production of adventitious roots along the stalk, but without other symptoms being present. Such cases have occurred in connection with root disease or insect injury.

Because of the close proximity of Santo Domingo and the fact that cane for milling is brought from there in large quantities by one of the Central companies, there has always been considerable interest taken in the cane fungi of this Island and the possibility of introducing new diseases to Porto Rico through this channel. Because of this threatening danger the senior author visited Santo Domingo some years ago making special search for diseases not already occurring Porto Rico and at the same time collecting all cane fungi found. A report of this trip was published at the time (49) and included mention of some five fungi causing the common diseases noted. Since that time determinations have been made of the other fungi collected and a complete list is here given with the localities in which found. It will be noted that no fungi are contained in the list not already reported as occurring in Porto Rico. All collections were made by Mr. Johnston, between April 4 and 20, 1913.

Cercospora vaginae Krüger.—Common at Higüral and other points.

Colletotricum falcatum Went.—San Pedro de Macoris, Santo Domingo City.

Craterium aureum (Shüm) Rost.—La Romana.

Diplodia cacaoicola. P. Henn.—La Romana, San Pedro de Macorís.

Graphium sacchari Speg.—La Romana.

Helminthosporium sacchari, Butler.—Higüral. Linear leaf spot.

Hormiactella sacchari Johnston.—San Pedro de Macorís.

Leptosphaeria sacchari. V. Breda de H.—La Romana. Common in all fields.

Lycogala epidendrum (L) Fr.—Higüral.

Marasmius sacchari Wakker.—Higüral, Santo Domingo City. As sterile mycelia only.

Melanconium sacchari Massee.—San Pedro de Macorís, La Romana. Common on ald cane.

Melanconium saccharinum Penz. & Sacc.—Higüral.

Nectria laurentiana Marchal.—San Pedro de Macorís.

Odontia saccharicola Burt.—La Romana.

Sclerotium sp. The gray form.—San Pedro de Macorís.

Schizophyllum commune Fries.—La Romana.

Sclerotium sp. The gray form.—San Pedro de Macorís.

Tetraploa aristata B & R.—San Pedro de Macorís.

Thielariopsis paradoxa (De Seynes) V. Hohn.—La Romana, Higüral.

Trametes nivosa (Berk) Murrill.—La Romana, Higüral.
Tubercularia saccharicola Speg.—Santo Domingo City.

CONTROL OF CANE FUNGI.

It is impracticable, in fact impossible, to entirely eliminate fungi from the cane fields. It is, rather, the aim of the good agriculturist, to produce as vigorous cane as possible and so reduce the fungi to a minimum. There are very few cane diseases that will not yield to proper agricultural methods combined with certain principles of control to be outlined here.

Space will not permit a consideration of the various points included under "proper agricultural methods," such as good drainage, irrigation when necessary, selection of seed, proper planting and cultivating. They are fully covered in other publications of this Station.

Among the control principles may be mentioned the following, a brief exposition of each being given.

1. Healthy seed only should be used for planting, since normal cane can hardly be expected from diseased seed. This means that all seed should undergo a careful selection to eliminate any that show borer or other insect injury, the presence of the mycelium of *Odontia* or other fungi, internal discolorations or rot due to *Melanconium, Colletotrichum, Diplodia*, or other cane-destroying agent. Seed selection should be carried out in the field where the cane is cut and not where it is to be planted.

2. Certain varieties of cane are more resistent to a given disease or diseases than others. An effort should be made to discover these by comparative tests and to use those that give the best results. The root disease often yields to a change in variety as do other diseases. Care should be exercised not to mix different varieties in the same field.

3. Certain diseases, particularly *Thielaviopsis*, are prevented by disinfection of the seed or by providing a protective covering. Bordeaux mixture is the only practicable substance for this purpose and gives good results where conditions are not favorable for quick germination or where the seed can not be planted at once.

4. Various other plants which harbor cane fungi should not be grown in rotation with cane or in the case of weeds they should be kept down as thoroughly as possible. This will apply especially to pineapples, which are very subject to *Thielaviopsis* and to various grasses attacked by *Odontia*, some of them of economic value. Permitting the land to revert to pasture after the cane is abandoned does not serve to kill out those fungi that attack the cane roots. It will

be far better to rotate cane with some leguminous crop, such as sword beans, cow-peas, or velvet beans.

5. Effort should be made to reduce to a minimum cane injured through attacks by borer, other insects, cattle, rats, or other agencies: such injured canes being readily attacked by various fungi. Gaining a foothold on injured canes, the fungi may spread to adjoining healthy cane.

6. Cane should not be allowed to become overmature, since many diseases are capable of causing severe damage to such cane. This applies particularly to *Melanconium* and *Colletotrichum* which often ruin whole fields of certain varieties. It must be noted that some varieties can be left until a second season without cutting, provided they are growing under good conditions, but they must be watched, since the disease, once it gets a foothold spreads very rapidly.

SUMMARY.

Fungi have caused heavy loss in the cane fields of Porto Rico. Diseases have been present in serious amounts since at least 1870 and are quite prevalent at the present time, presenting a number of difficult problems. Cane diseases have been studied in Porto Rico by various agronomists and commissions of the Spanish times and since the American occupation to some extent by the Federal Experiment Station. Most of the work in this field has been carried out by pathologists of what is now the Insular Experiment Station.

There are a considerable number of important cane diseases not occurring in Porto Rico, "sereh," gumming, etc.

Of the fungi found chiefly on the roots or base of the stalk are *Marasmius sacchari*, *Himantia stellifera*, and *Odontia sacchari*. These are all concerned to a greater or less extent in the so-called root disease. Studies on their exact relationships and parasitism have not yet been carried out.

The principal diseases of the stalk are red rot (*Colletotrichum falcatum*, rind disease, (*Melanconium sacchari*), and a new disease due to *Cytospora sacchari*, which proved threatening to certain varieties. The two former diseases especially attack overmature or injured cane.

A number of leaf diseases are found, none of which cause appreciable loss although they are of universal occurrence. Those described are red spot of the leaf-sheath (*Cercospora vaginae*), red rot of the leaf-sheath (*Sclerotium Rolfsii*), eye spot (*Helminthosporium sacchari*), ring spot (*Leptosphaeria sacchari*), brown leaf spot (*Cercospora longipes*), red stripe, and wither-tip.

The only important disease of cane cuttings is that due to *Thielaviopsis paradoxa*, readily prevented by dipping the seed in Bordeaux mixture.

Under the heading of minor fungi and diseases seventy-two fungi are listed, together with notes of occurrence, and the symptoms of any diseases they may cause.

Chlorosis a disease characterized by a yellowing or whitening of the leaves and occurring in certain districts on the south coast, is described together with experiments for its control. Yellow striping is a phenomenon occurring to a very limited extent.

An account is given of the new disease, or mottling of cane, a phenomenon existing in the western end of the Island. It is characterized by a peculiar mottling of the leaves, and later by a cankering of the stalks. All varieties are attacked, and it has occasioned very heavy losses. No certain control measures are known.

Injuries due to natural agencies, lightning, wind, floods, and drouth are discussed.

Certain abnormalities are mentioned, but are of little importance.

A list of the cane fungi of Santo Domingo is appended.

Certain of the principles of control of cane diseases are briefly outlined.

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EXPLANATION OF PLATES.

PLATE XIX.

Fig. 1.—*Odontia saccharicola* (Slightly reduced.)

Fig. 2.—*Himantia stellifera.* Mycelium on leaf-sheath. X 1.

Fig. 3.—*Thielaviopsis paradoxa.* Section of infected cane cutting. X 1.

PLATE XX.

Fig. 1.—*Marasmius sacchari.* Sporophores X 1.

Fig. 2.—*Monilia sitophila.* X 1.

Fig. 3.—*Melanconium sacchari.* Showing pustules on stalk. X 1.

Fig. 4.—*Colletotricum falcatum.* Black fruiting areas on exposed surface of inoculated seed piece X 1.

PLATE XXI.

Fig. 1.—*Diplodia cacaoicola.* Erumpent clusters of pycnidia. X 2.

Fig. 2.—*Polystictus occidentalis.* X 1.

Fig. 3.—*Valsaria subtropica.* X 2.

Fig. 4.—*Trichoderma lignorum.* X 2.

PLATE XXII.

Fig. 1.—*Cytospora sacchari.* Showing beaked pycnidia. X 2.

Fig. 2.—*Cytospora sacchari.* Cankers produced on cane stalk. Slightly reduced.

Fig. 3.—*Polystictus sinuosus.* X 1.

Fig. 4.—*Schizophyllum commune.* X 1.

PLATE XXIII.

Fig. 1.—*Hypocrea rufa.* X 2.

Fig. 2.—*Gibberella pulicaris.* X 2.

Fig. 3.—*Tubercularia saccharicola.* X 2.

Fig. 4.—*Sphaerobolus stellatus.* X 2.

Fig. 5.—*Lycogala epidendrum.* X 2.

Fig. 6.—*Cyathus Poeppigii* X 2.

PLATE XXIV.

Fig. 1.—*Cercospora vaginae.* X ½.
Fig. 2.—*Melanconium saccharinum* X 2.
Fig. 3.—*Spegazzinia ornata.* X 4.
Fig. 4.—*Phyllosticta sacchari.* Slightly reduced.

PLATE XXV.

Fig. 1.—*Leptosphaeria sacchari.* X 1.
Fig. 2.—The "smaller" leaf spot X 1.
Fig. 3.—*Sclerotium Rolfsii.* X 2.
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Fig. 5.—*Arcyria cinera.* X 2.
Fig. 6.—Red stripe of the leaf. X 1½.

PLATE XXVI.

Fig. 1, 2.—*Sphaerobolus stellatus.* Gross appearance.
Fig. 3.—*Sphaerobolus stellatus.* Spores.
Fig. 4.—*Asterostroma cervicolor.* Stellate appendage of mycelium.
Fig. 5.—Same, immature condition.
Fig. 6, 7.—*Asterostroma cervicolor.* Basidia and spore.
Fig. 8, 9.—*Marasmius sacchari.* Gross appearance.
Fig. 10.—*Marasmius sacchari.* Spore.
Fig. 11.—*Odontia sacchari.* Cystidium.
Fig. 12.—*Odontia sacchari.* Basidium with one spore.
Fig. 13.—*Peniophora sp.*, Basidium and spores.
Fig. 14.—*Peniophora sp.*, Cystidium.
Fig. 15, 17.—*Marasmius borinquensis.* Gross appearance.
Fig. 16.—*Marasmius borinquensis.* Spore.
Fig. 18.—*Trogia sp.* Gross appearance.
Fig. 19.—*Trogia sp.* Spore.

PLATE XXVII.

Fig. 1.—*Hypocrea rufa.* Diagrammatical section of stroma, showing position of perithecia.

Fig. 2.—*Hypocrea rufa.* Ascus and spores.

Fig. 3.—*Tapesia sp.* Apothecia in various stages.

Fig. 4.—*Tapesia sp.* Ascus and spores.

Fig. 5.—*Tubercularia saccharicola.* Diagrammatic vertical section of sporodochia.

Fig. 6.—*Tubercularia saccharicola.* Spores.

Fig. 7.—*Tubercularia saccharicola.* Conidiophores.

Fig. 8.—*Chromocrea gelatinosa.* Diagrammatic vertical section of stroma.

Fig. 9.—*Chromocrea gelatinosa.* Portion of ascus.

Fig. 10.—*Chromocrea gelatinosa.* Spore.

Fig. 11.—*Volutina sp.* Sporodochium, much enlarged.

Fig. 12.—*Volutina sp.* Conidia.

Fig. 13.—*Volutina sp.* Portion of seta.

Fig. 14.—*Gibberella pulicaris.* Ascus.

Fig. 15.—*Gibberella pulicaris.* Spores.

Fig. 16.—*Nectria flavociliata.* Perithecium.

Fig. 17.—*Nectria flavociliata.* Portion of seta.

Fig. 18.—*Nectria flavocilata.* Ascus and spores.

Fig. 19.—*Tetracoccosporis sacchari.* Fertile hypha.

Fig. 20.—*Tetracoccosporis sacchari.* Conidium.

Fig. 21.—*Nectria laurentiana.* Habit sketch of perithecia.

Fig. 22.—*Nectria laurentiana.* Ascus.

Fig. 23.—*Nectria laurentiana.* Spore.

Fig. 24.—*Valsaria subtropica.* Ascus.

Fig. 25.—*Valsaria subtropica.* Spore.

Fig. 26.—*Valsaria subtropica.* Diagrammatic vertical section, showing perithecia.

PLATE XXVIII.

Fig. 1.—*Cytospora sacchari.* Diagrammatic vertical sections of stromata.

Fig. 2.—*Cytospora sacchari.* Conidium.

Fig. 3.—*Cytospora sacchari.* Diagrammatic cross-section of stroma.

Fig. 4.—*Cytospora sacchari.* Conidiophore.

Fig. 5.—*Melanconium saccharinum.* Conidia.

Fig. 6.—*Vermicularia graminicola.* Habit sketch.

Fig. 7.—*Vermicularia graminicola.* Conidium.

Fig. 8.—*Vermicularia graminicola.* Pycnidium.

Fig. 9.—*Colletotrichum falcatum.* Conidium.

Fig. 10.—*Colletotrichum C.* Conidium.

Fig. 11.—*Colletotrichum C.* Condia, setae, conidiophores.

Fig. 12.—*Colletotrichum C.* Setae.

Fig. 13.—*Colletotrichum falcatum.* Acervulus.

Fig. 14, 16, 17.—*Colletotrichum falcatum.* Conidia and conidiophores, showing variation in conidia.

Fig. 15.—*Colletotrichum A.* Conidia and conidiophore.

Fig. 18, 19, 20.—*Colletotrichum B.* Conidia and conidiophores.

PLATE XXIX.

Fig. 1.—*Arthrinium saccharicola.* Fertile hypha.
Fig. 2.—*Arthrinium saccharicola.* Base of fertile hypha.
Fig. 3.—*Arthrinium saccharicola.* Conidium.
Fig. 4.—*Helminthosporium sacchari.* Conidium.
Fig. 5.—*Helminthosporium sacchari.* Conidiophores.
Fig. 6.—*Spegazzinia ornata.* Conidiophore and conidia.
Fig. 7.—*Spegazzinia ornata.* Immature conidia.
Fig. 8.—*Thielaviopsis paradoxa.* Microconidia.
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Fig. 10.—*Thielaviopsis paradoxa.* Micro-and macro-conidiophores.
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Fig. 16.—*Periconia sacchari.* Condidiophore and conidia.
Fig. 17.—*Periconia sacchari.* Mode of branching.
Fig. 18.—*Periconia sacchari.* Conidium.
Fig. 19.—*Cercospora vaginae.* Conidiophores.
Fig. 20.—*Cercospora vaginae.* Conidia.

PLATE XXX.

Fig. 1.—*Hormiactella sacchari.* Portion of conidiophore.
Fig. 2.—*Hormiactella sacchari.* Portion of conidiophore and conidia.
Fig. 3.—*Hormiactella sacchari.* Mode of branching.
Fig. 4. 5.—*Hormiactella sacchari.* Habit sketches.
Fig. 6.—*Trichoderma lignorum.* Conidiophores.
Fig. 7.—*Arthrobotrys superba.* Conidiophore and conidium.
Fig. 8.—*Arthrobotrys superba.* Conidium.
Fig. 9.—*Arthrobotrys superba.* Portion of fertile hypha.
Fig. 10.—*Trichoderma lignorum.* Same as fig. 6. Enlarged.
Fig. 11. 12.—*Trichoderma lignorum.* Mode of formation of conidia.

PLATE XXXI.

Fig. 1.—*Himantia stellifera.* Diagrammatic cross-section of cane rootlet, showing at X location of crystal bearing hyphae.

Fig. 2.—*Himantia stellifera.* Portion of section shown in Fig. 1, enlarged.

Fig. 3.—*Himantia stellifera.* Hypha and crystal.
Fig. 4.—*Himantia stellifera.* Swollen tips of hyphae.
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PLATE XIX.

Sugar-cane Fungi of Porto Rico.

PLATE XX.

Sugar-cane Fungi of Porto Rico.

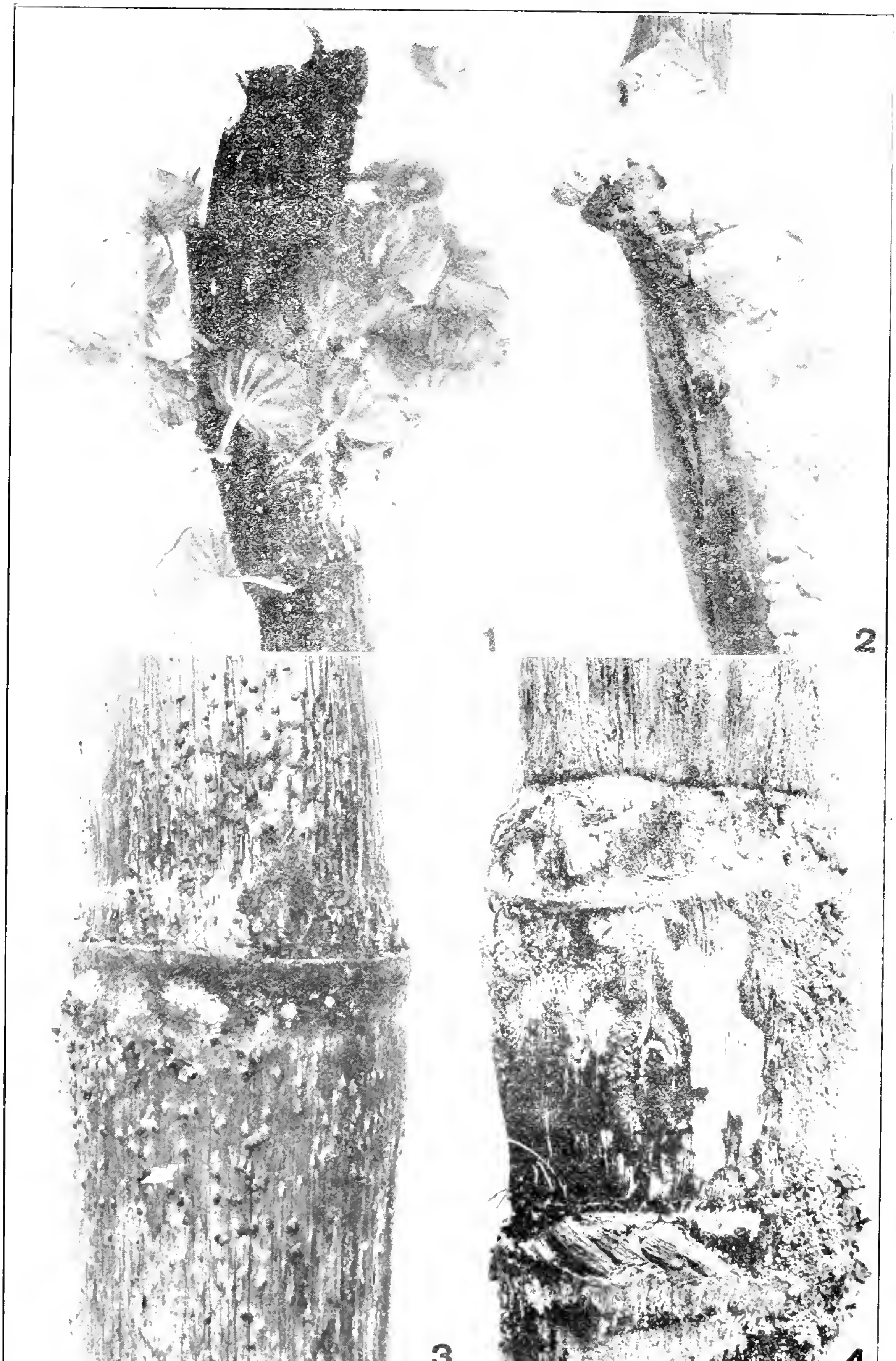

PLATE XXI.

Sugar-cane Fungi of Porto Rico.

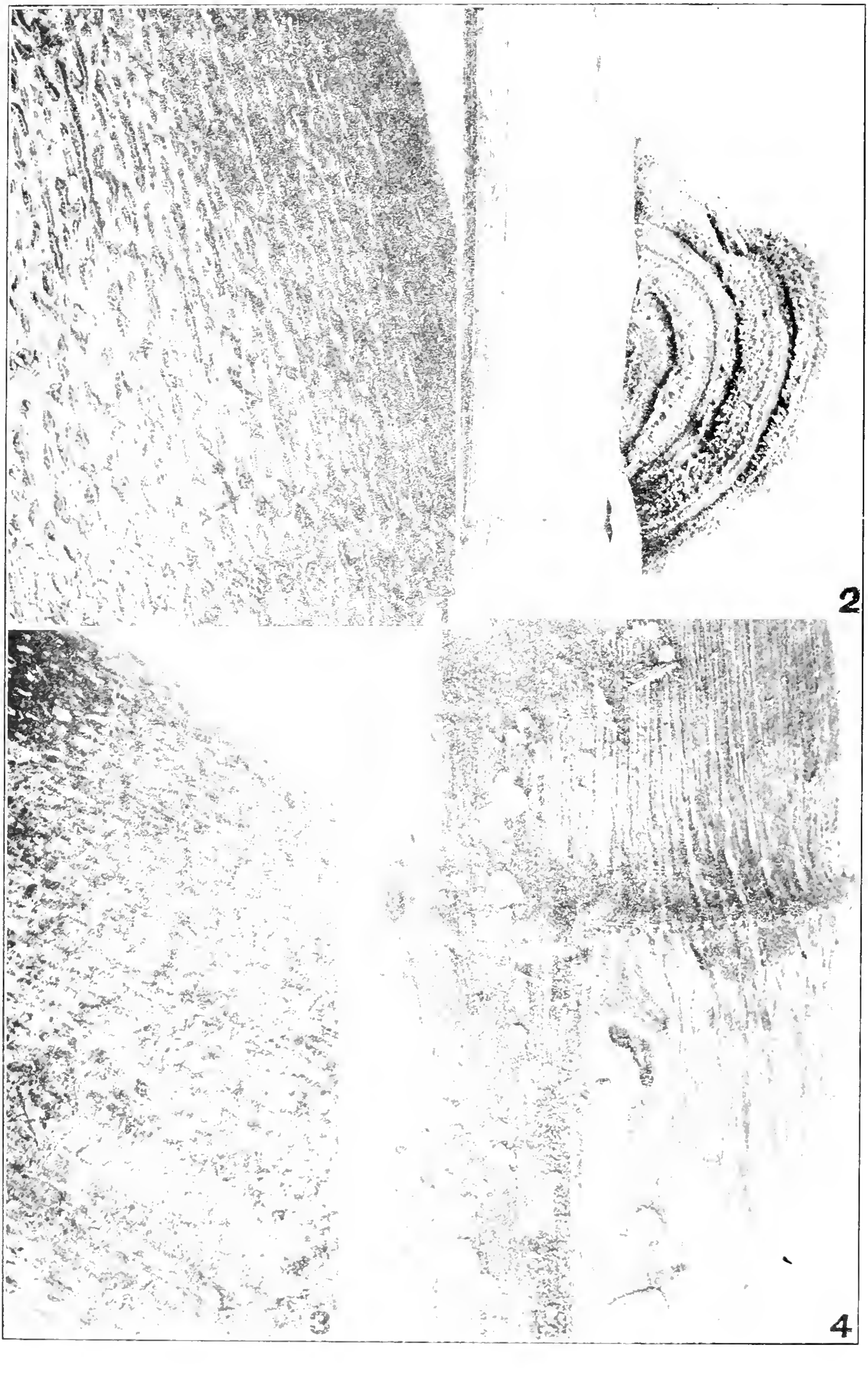

PLATE XXII.

Sugar-cane Fungi of Porto Rico.

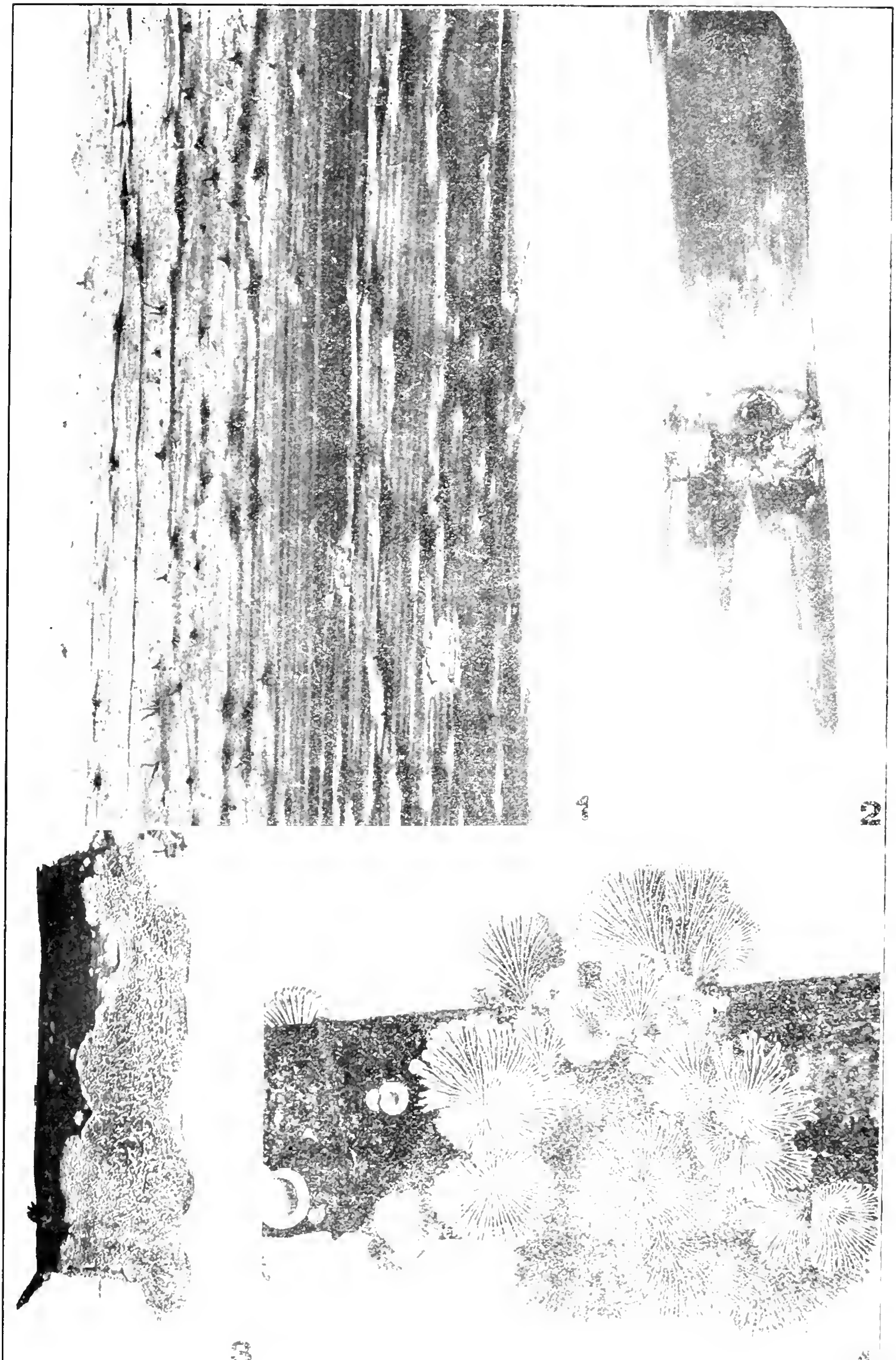

PLATE XXIII.

Sugar-cane Fungi of Porto Rico.

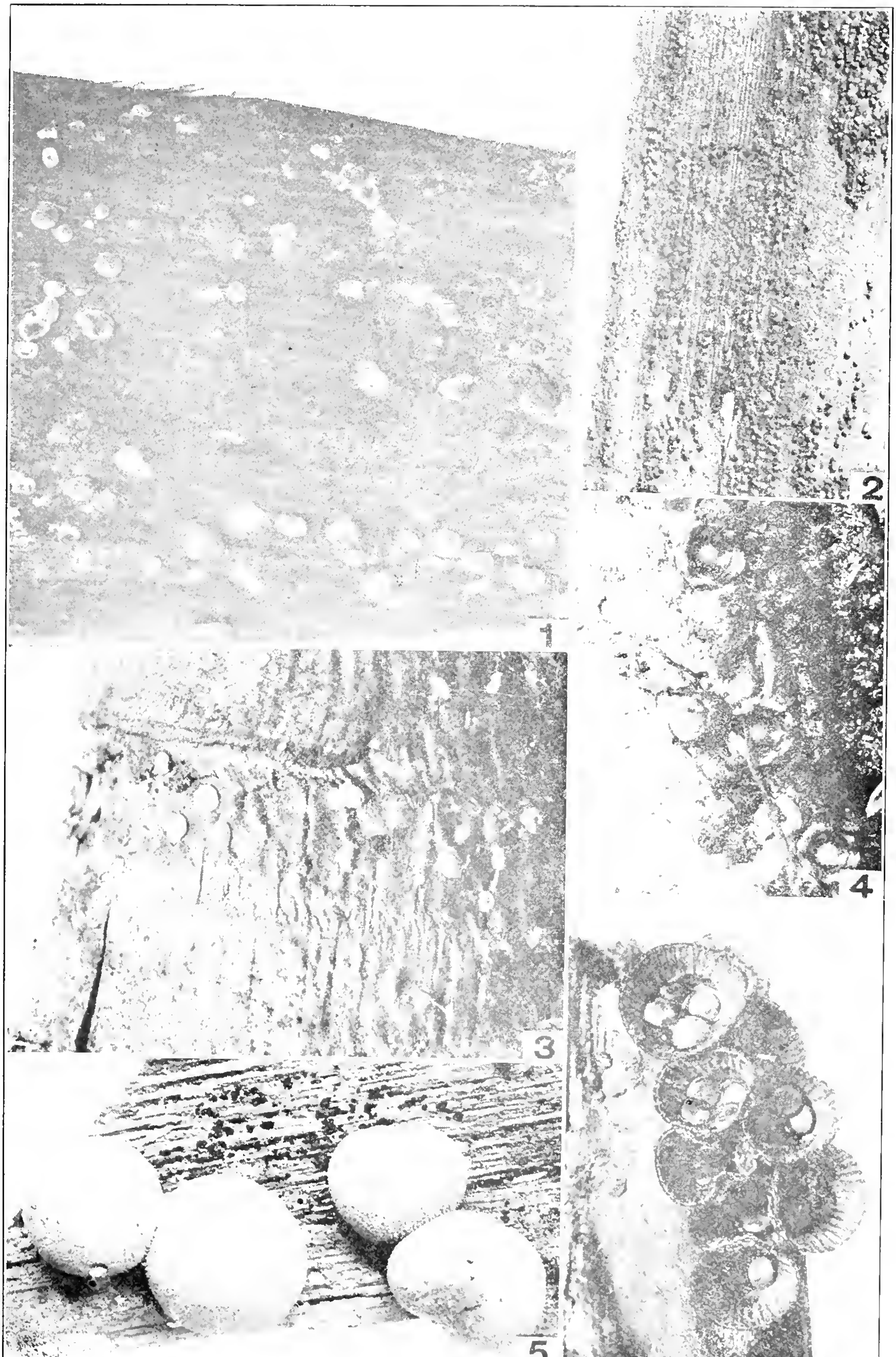

PLATE XXIV.

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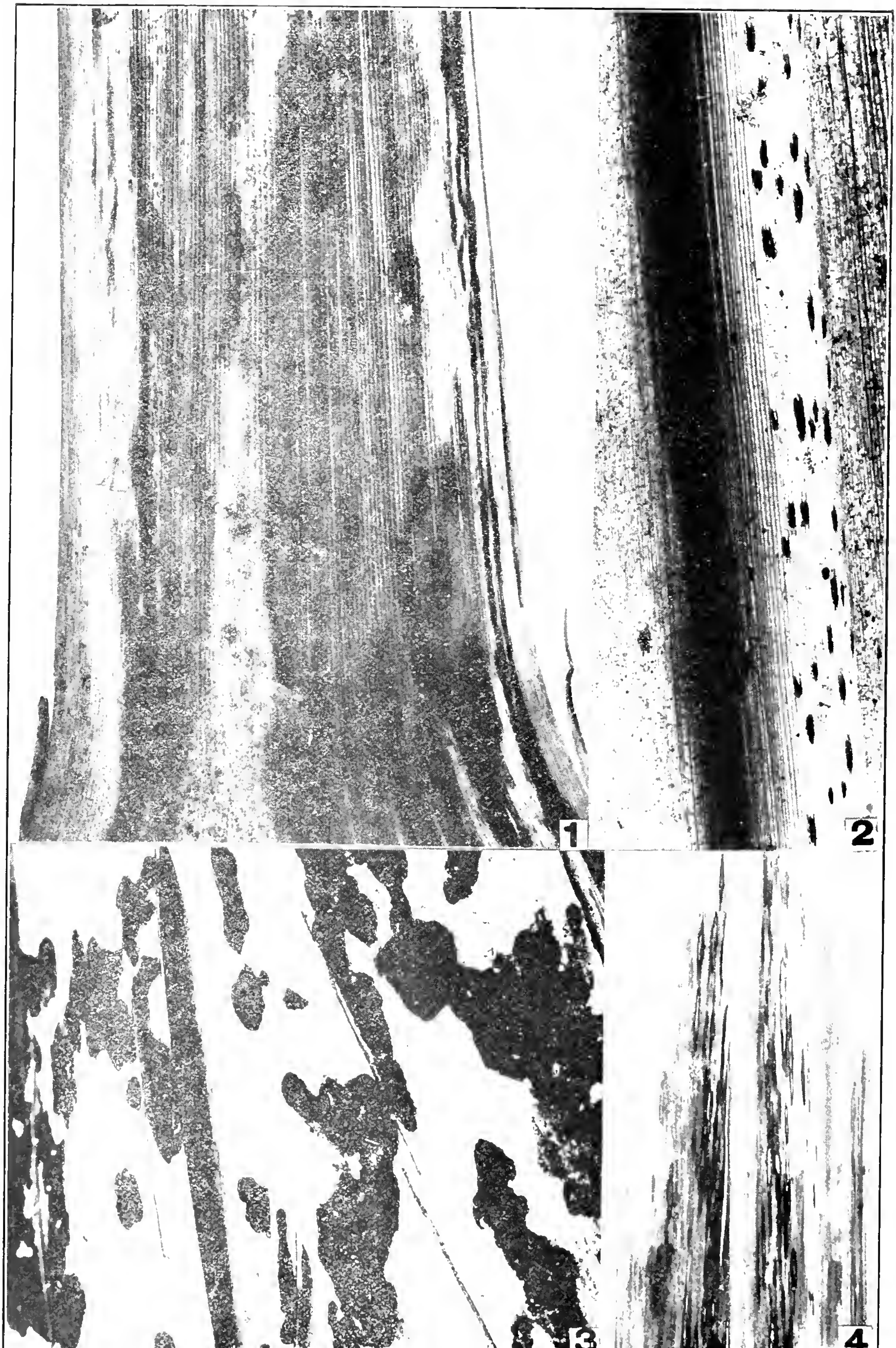

PLATE XXV.

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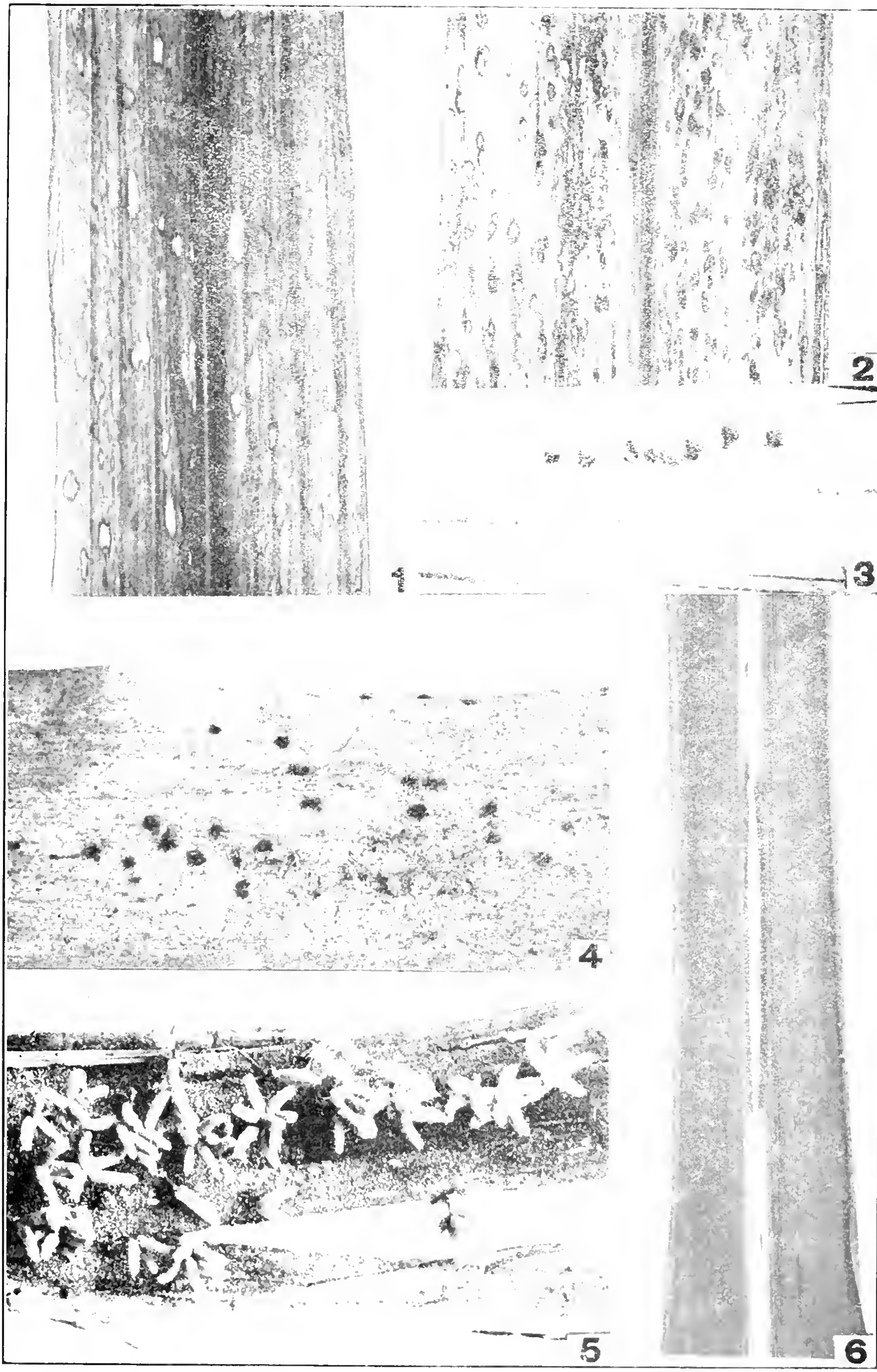


PLATE XXVI.

Sugar-cane Fungi of Porto Rico.

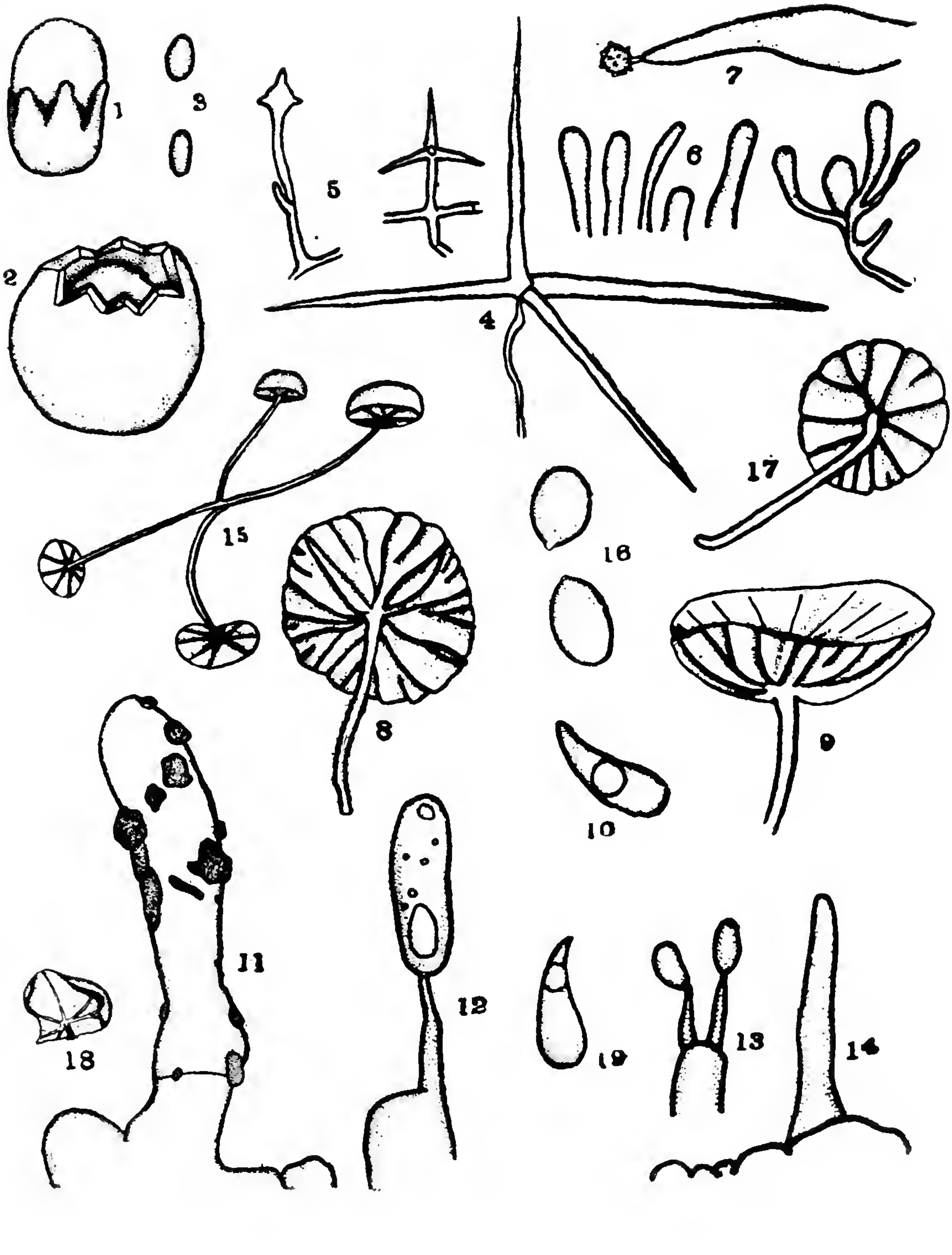


PLATE XXVII.

Sugar-cane Fungi of Porto Rico.

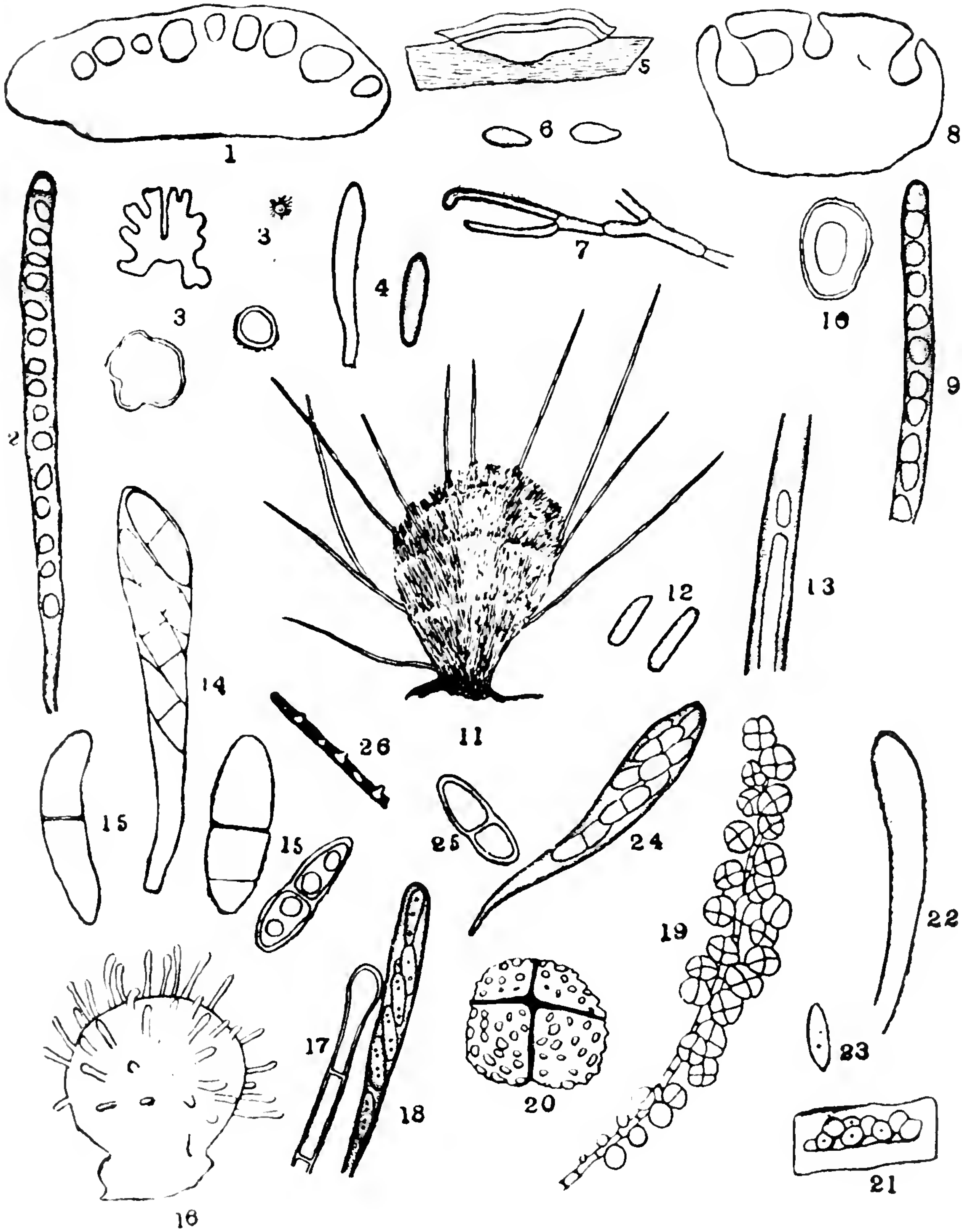


PLATE XXVIII.

Sugar-cane Fungi of Porto Rico.

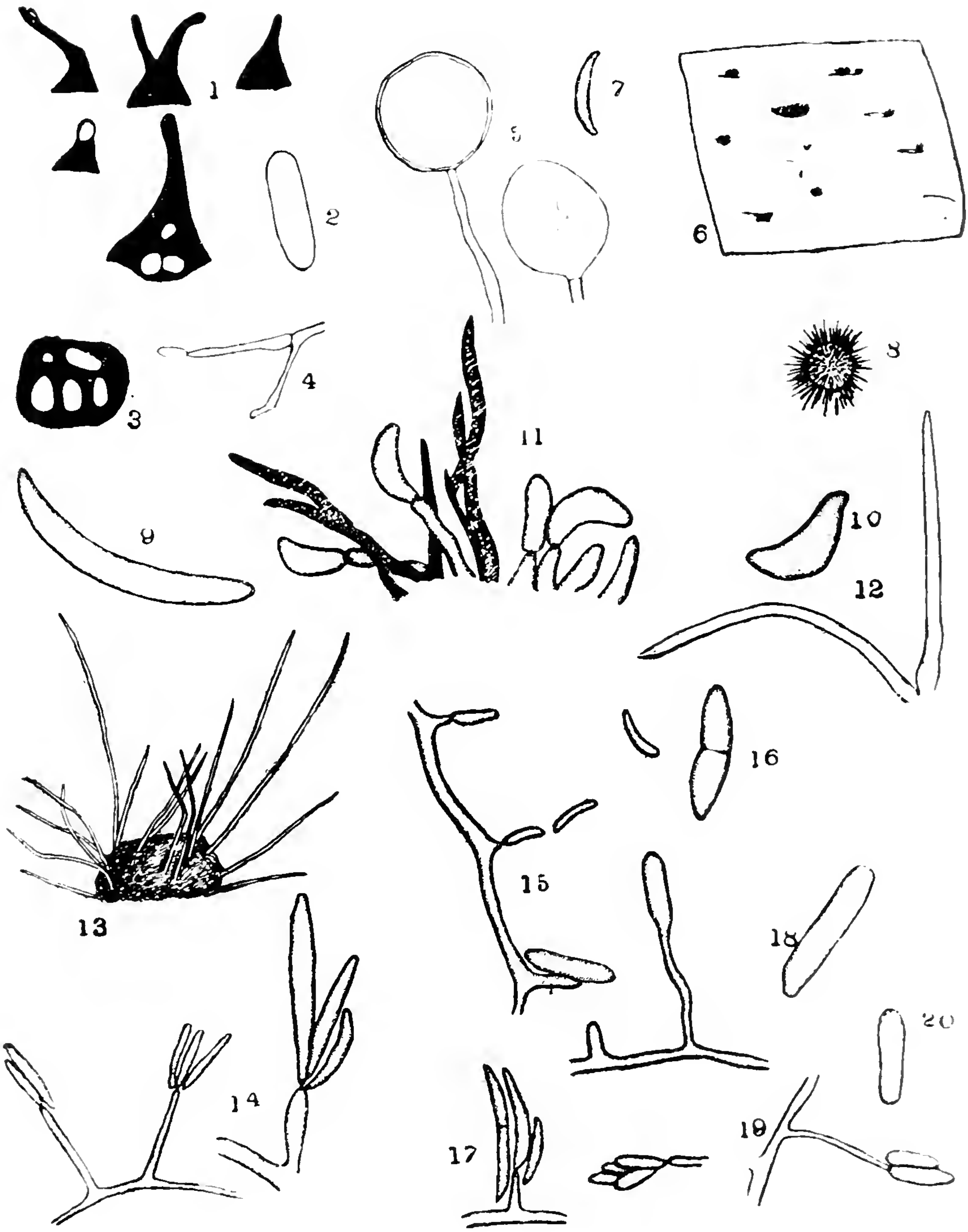


PLATE XXIX.

Sugar-cane Fungi of Porto Rico.

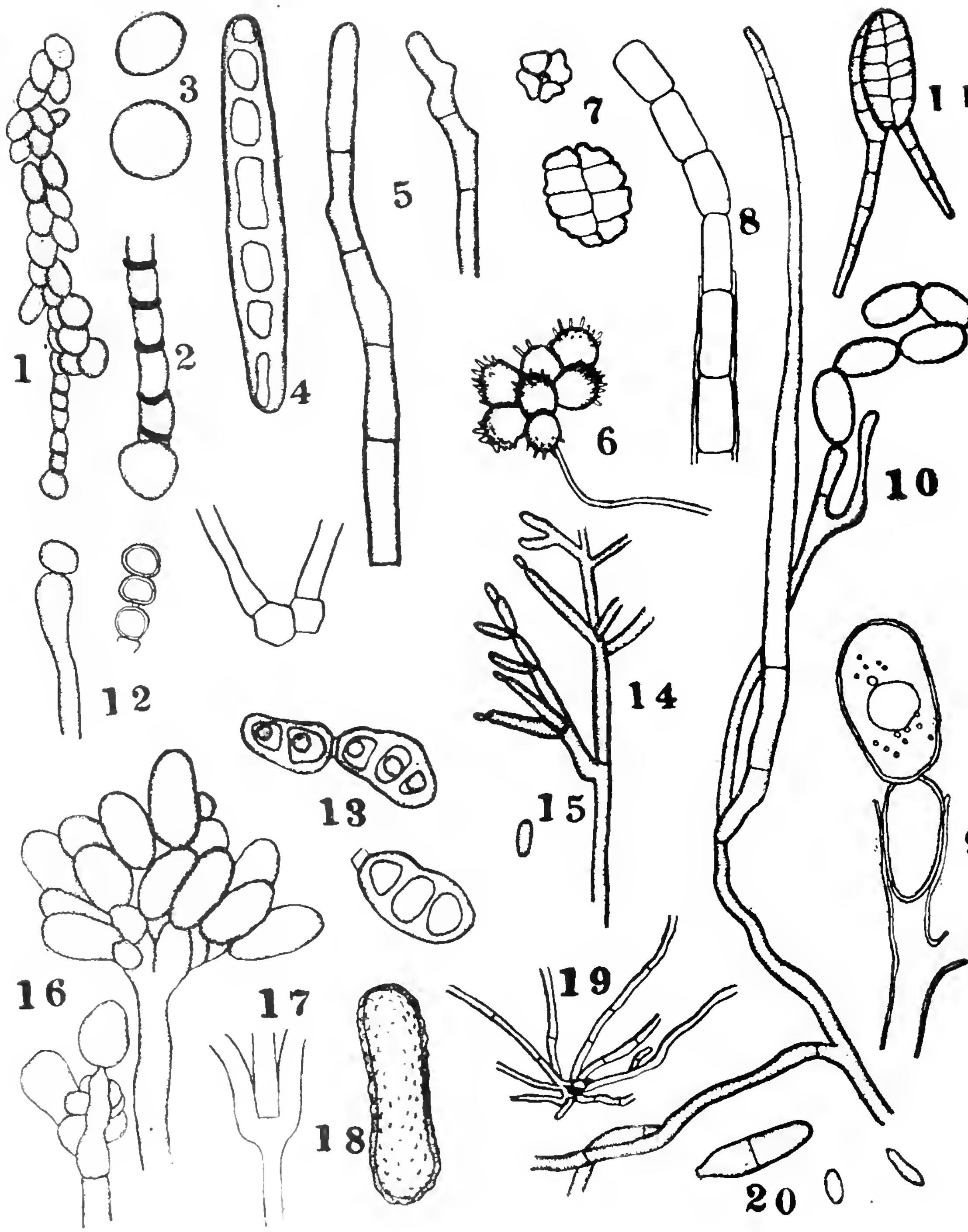


PLATE XXX.

Sugar-cane Fungi of Porto Rico.

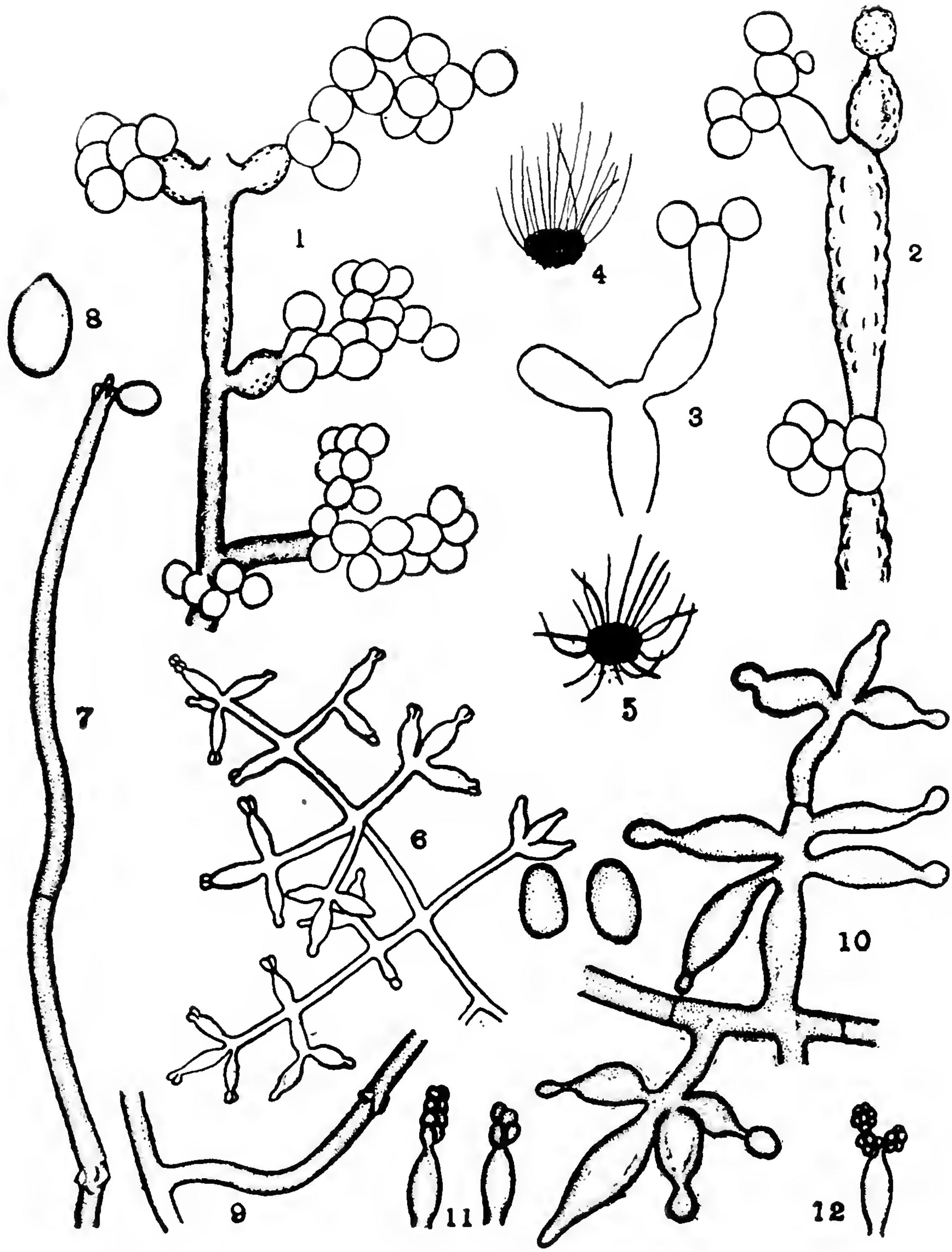
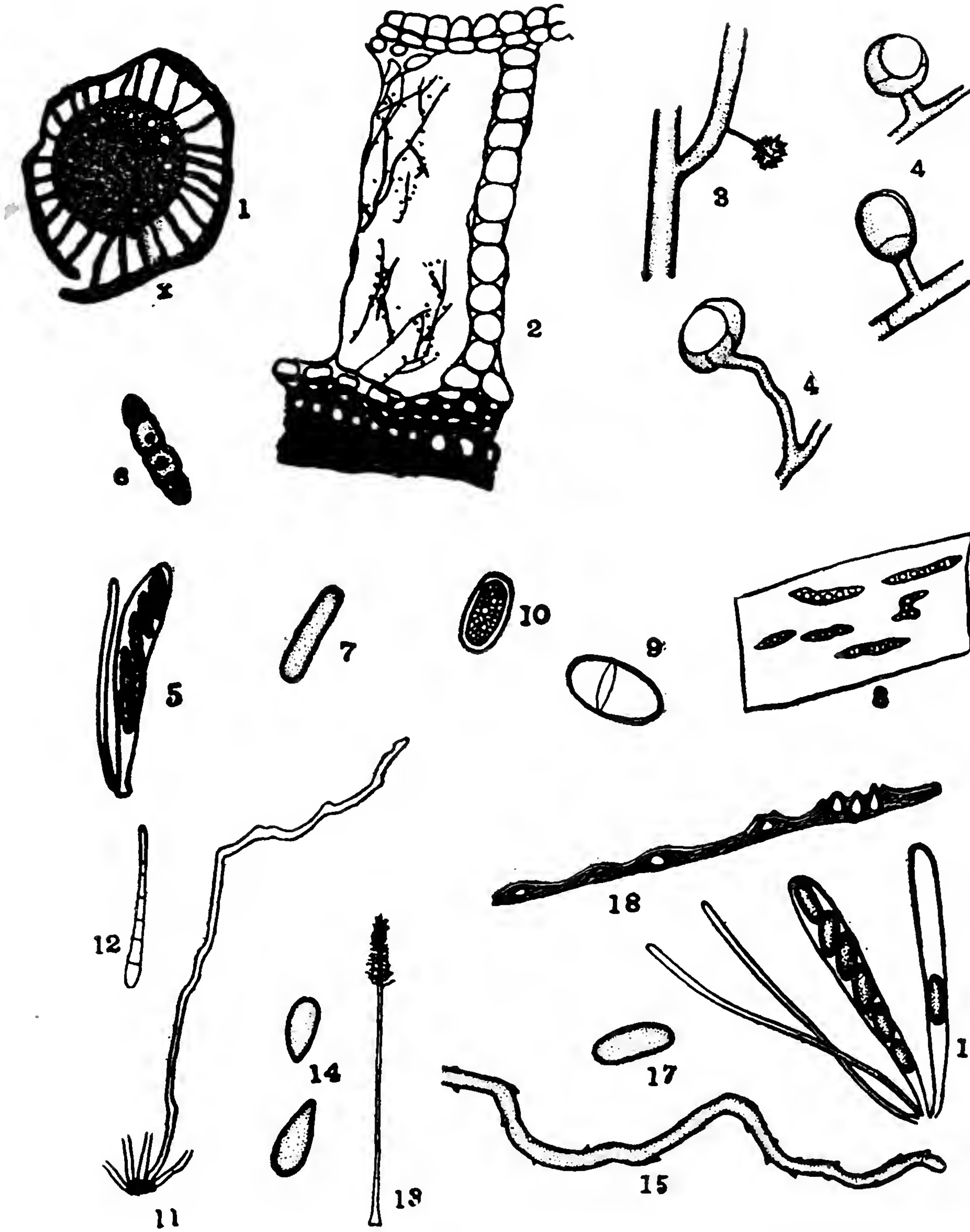


PLATE XXXI.

Sugar-cane Fungi of Porto Rico.



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THE JOURNAL
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EXPERIMENTAL WORK ON THE CONTROL OF THE WHITE GRUBS OF PORTO RICO.

By R. T. COTTON, Entomologist, Insular Experiment Station.

The white grubs of Porto Rico are known to have been present and doing damage on the Island for the last twenty-five years. How serious their ravages were previously we do not know, but since that time they have become gradually more and more destructive, until at present it is impossible to grow ratoon cane in some sections of the Island.

During the year of 1908 the sugar cane in the district of Guánica Central began to suffer very noticeably from the attack of the white grubs, and the following year, matters becoming still worse, strenuous measures were started for discovering methods of controlling this serious pest.

From that time until the present, numerous and varied experiments have been conducted by various entomological workers of the Insular Experiment Station of Río Piedras and the Federal Experiment Station, both independently, and in co-operation with the management of Guánica Central and other centrals of the Island.

No report has ever been published on the results of the vast amount of experimental work conducted along these lines, and although the majority of the results are of a negative nature, they are of considerable interest and some value to entomological workers. Therefore the writer has prepared this brief review.

A considerable portion of the work was carried out by the late Mr. C. T. Murphy, in charge of the experimental work at Guánica, in co-operation with Mr. W. V. Tower, formerly entomologist of the Federal Experiment Station at Mayagüez, and Mr. D. L. Van Dine, former entomologist of the Experiment Station of the Sugar Producers' Association of Porto Rico. Portions of the work have also been conducted by Messrs. Thos. H. Jones and G. N. Wolcott,

former entomologists of the Insular Experiment Station, and by former assistant entomologist Eugene G. Smyth. Mr. R. H. Van Zwaluwenburg, entomologist of the Federal Experiment Station at Mayagüez, has also carried out work along this line, as is noted hereafter. Credit is due to all of these workers for the data given below.

Mr. Eugene G. Smyth, who has recently published an article[1] on the white grubs injuring sugar cane in Porto Rico, states that ten distinct species of white grubs have been segregated and studied. Of these, four belong to the genus *Phyllophaga* and one to the genus *Phytalus* in the tribe *Melolonthini*, while the other five belong to three genera in the tribe *Dynastini*.

It was in connection with the members of the genus *Phyllophaga* that most of the experimental work was conducted and to which the following data apply.

The various experiments have been grouped according to the following headings: soil fumigants, soil insecticides, mechanical methods, poison sprays, and parasitic insects and diseases. Space does not permit the publication of all the experiments conducted in some cases, so selections have been taken that represent the typical results obtained in each group.

SOIL FUMIGANTS.

Under this heading have been grouped the experiments conducted with carbon bisulphide, gasoline, tobacco extract, potassium cyanide, and vaporite, since in all cases the gases or fumes given off by these substances were depended upon to kill the grubs.

Carbon bisulphide.

To test the value of carbon bisulphide as a killing agent, to determine the best method of application, and the most efficient amount of the liquid to use, the two following experiments were made. They were conducted in cane land severely infested with grubs:

Experiment 1.—Use of Carbon Bisulphide in Killing the White Grub.

No. of plot	No. of stools of cane	Amount CS_2 applied	How applied	When examined	Average No. grubs per stool	No. of grubs after treatment: Alive	No. of grubs after treatment: Dead	Per cent of grubs killed
1	4	25cc.	Hole in center of stool.	18 hours later	8	11	21	65
2	4	50cc.	"	"	16	5	60	92
3	4	25cc.	In 2 holes at side of stool	"	15	52	9	14
4	4	50cc.	"	"	10	35	6	14
5	4	25cc.	In 1 hole at side of stool	"	17	52	15	24
6	3	50cc.	"	"	6	25	1	4

[1] Journal of the Dept. of Agric. of P. R., Vol. 1, no. 2., pp. 47–92, no. 3, pp. 141–169.

Experiment II.—Use of Carbon Bisulphide in Killing White Grubs.

No. of plot	No. of stools of cane	Amount CS2 applied	How applied	Depth of injection	When examined	Per cent of grubs killed
1	10	12.5 cc.	Center of stool	5 inches	5 days later	60
2	"	25 cc.	"	"	"	65
3	"	50 cc.	"	"	"	75
4	"	25 cc.	12.5 cc. each side of stool	"	"	78
5	"	50 cc.	25 cc. on each side of stool	"	"	76
6	"	"	In center of stool	3 inches	"	90
7	"	"	"	"	"	66

As a result of these experiments it was seen that carbon bisulphide was a good killing agent, and that the best results were obtained by putting the charge in the center of the stools of cane at a depth of about three inches. It was also noted, however, that severe injury resulted to the cane plants from the carbon bisulphide when amounts greater than 12.5 cc. were used.

An experiment was then conducted at Guánica Central, under the direct supervision of Mr. C. T. Murphy, to test out the value of carbon bisulphide on a field scale. Some thirty-three odd acres of land planted to sugar cane were used, arranged in five different sections of 3, 3, 4, 6, and 4 plots, respectively. One check plot was left in each section.

The carbon bisulphide was injected by the use of several "Pal Injecteurs" imported from Germany at a cost of $31.57 each. They were so arranged that any amount of liquid desired could be injected at one time. The only drawback in the use of these instruments was the action of the carbon bisulphide on the rubber connections and leather washers. These very quickly disintegrated, and the small pieces of rubber and leather clogged up the holes through which the liquid was forced. Specially devised rubber connections finally overcame this difficulty, however.

Carbon bisulphide was found to be a most disagreeable and dangerous liquid to handle, for although no serious accidents happened, numerous burns about the hands and face were experienced by the men who applied it.

In all, eight thousand eight hundred pounds of this material were used in the experiment at a cost of six cents a pound. The cost of application was $67.05. The cost of material and labor for the application of fifteen grams per stool of cane amounted to $15.53 per acre; for the application of thirty grams per stool, $31.06 per acre. The following tables give the results of the experiment:

Experiment III.—Results Obtained from Treatment with Carbon Bisulphide.[1]

No. of Section	No. of plot	Amount CS_2 applied per stool and how applied	When applied	No. of acres in plot	Weight in tons per acre of cane harvest	Increase or decrease compared with check in tons of cane per acre	Brix	Sucrose	Purity	Tons available 96% sugar per acre	Infestation by grubs[1] at harvest time
1	1	15 grams each side of bank	November 10	.85	38.85	+ 1.41	16.2	12.8	79.0	3.72	Grubs fairly numerous.
	2	Check		.96	37.44		15.6	12.6	80.5	3.56	
	3	15 grams in bank, 15 in furrow	November 10	1.04	35.52	— 1.92	15.7	12.2	77.9	3.21	Grubs very numerous.
2	1	15 grams center of bank	November 10	1.62	43.51	+ 1.46	No mill test taken for this section.				Very few grubs in all three plots.
	2	30 grams center of bank	November 10	1.62	41.12	— .93					
	3	Check		1.62	42.05						
3	1	15 grams in side of bank	November 10	1.95	31.10	— .28	16.3	13.5	82.2	3.20	Grubs very numerous.
	2	15 grams in furrow	November 10	3.54	45.22**	+13.84	17.4	15.3	87.6	5.15	Very few grubs.
	3	Check		1.85	31.38		17.0	14.5	86.6	3.57	
	4	15 grams center of bank	November 10	7.89	33.31	+ 1.96	17.5	15.0	85.4	3.90	
4	1	15 grams center	November 10	.51	31.68	+11.68	16.5	13.1	79.4	3.11	All these plots had an average of 3 grubs per stool.
	2	15 grams each side	November 10	.58	19.72	— .28	17.2	11.2	82.5	2.11	
	3	Check		.61	20.00		16.4	11.5	71.0	1.66	
	4	15 grams center	November 10	1.95	27.27	7.27	15.7	12.7	81.0	2.63	
	5	15 grams bank, 15 grams furrow	November 10	.79	20.12	+ .12	16.6	13.8	83.0	2.13	
	6	15 grams furrow	November 10	.66	28.68	+ 8.68	16.3	13.1	80.1	2.83	
5	1	15 grams center	November 10	.83	30.96	— .41	17.1	11.3	83.6	3.41	Few grubs.
	2	Check		1.03	31.37		16.4	13.4	81.1	3.19	
	3	15 grams in side	November 10	1.71	16.59	—14.78	16.4	13.5	82.3	1.71	Many grubs
	4	15 grams center	November 10	1.14	21.60	— 9.77	17.0	14.2	81.2	2.37	

[1] Canes were planted during September and October of 1910, and were reaped November 15, 1911—January 13, 1912.

** Increase due to better soil.

All plots in this experiment received the same cultural treatment. The only factor that could not be controlled was the condition of the soil. In section four the check plot unfortunately fell upon a piece of bad soil which reduced the yield at least ten tons below the average normal crop per acre. If we disregard this plot, we then find that on six of the ten treated plots the yield fell below the check plots. In all cases where a double dose was applied the yield was lower than on the check plot. The carbon bisulphide had a detrimental effect on the growth of the cane plants.

Altogether the results do not warrant a further use of carbon bisulphide as a means of control for the white grubs in growing cane, for although it may kill the grubs in the stool when first applied the effect is not lasting, and as the egg-laying season of the beetle extends over a rather long period the land soon becomes reinfected and at least three applications a season would be necessary to keep the land free from the grubs. The expense of the material would in any case render such an operation prohibitive. The liquid is dangerous and disagreeable to handle, and furthermore it is injurious to the cane, stunting its growth and often killing the plant.

Carbon bisulphide and gasoline.

In an endeavor to find a mixture that would be cheaper and less injurious to plant life than carbon bisulphide, experiments were tried with gasoline and various mixtures of gasoline and carbon bisulphide. The following table shows the results obtained:

Experiment IV.—Use of Carbon Bisulphide and Gasoline Against White Grubs.

No. of plot	No. of stools of cane	Liquid used	Amount per stool	Where applied in stool	Grubs found after treatment		Per cent grubs killed
					Alive	Dead	
1	10	Pure CS_2	20 grams	Center	6	150	96
2	10	Gasoline	20 "	"	20	117	93
3	10	CS_2—1/3 Gas—2/3	" "	"	10	179	95
4	5	" "	10 "	"	31	57	65
5	5	" "	10 "	"	2	59	97
6	10	CS_2—1/2 Gas—1/2	20 "	"	18	127	87
7	3	" "	10 "	"	9	18	66
8	5	" "	40 "	"	6	66	91

All experiments conducted with these two liquids consistently showed that they had almost equal killing powers and could be mixed as desired. However, when applied to young cane all the mixtures

in quantities of twenty grams or more severely burned the plants, and even with mature cane severe injury resulted.

Hence it was found impossible to use gasoline as a substitute or as an adulterant for carbon bisulphide. The great increase in the cost of gasoline at the present time would of course preclude its use, even had it proved to be non-injurious to plant life.

Potassium cyanide.

In view of the deadly nature of potassium cyanide and of reports of its successful use in controlling certain forms of subterranean insects, it seemed desirable to try it out against the white grubs. Experiments were accordingly carried out in which potassium cyanide in both liquid and crystal form was applied in various amounts and at varying depths in the soil, around the roots of the sugar cane.

The potassium-cyanide solution was prepared by dissolving two hundred grams of the crystals in a liter of water. Five grams of the crystals were thus equivalent to twenty-five cc. of solution. For purposes of comparison equivalent amounts of potassium cyanide were used in both experiments. The following tables show the results obtained:

Experiment V.—Experiment with Potassium Cyanide in Liquid Form.

Plot No.	No. of stools of cane	Amount applied	How applied	Depth applied	When applied	When examined	No. grubs found	
							Alive	Dead
1	8	25cc.	Center of stool	3 inches	Feb. 21	March 3	81	13
2	8	" "	"	5 "	" "	" "	87	7
3	7	50 "	"	3 "	" "	" "	39	25
4	7	" "	"	5 "	" "	" "	71	16

Experiment VI.—Experiment with Potassium Cyanide in Crystal Form.

Plot No.	No. of stools of cane	Amount applied	How applied	Depth applied	When applied	When examined	No. grubs found	
							Alive	Dead
1	1	5 grams	Center of stool	5 inches	Feb. 21	Feb. 28	11	2
2	1	" "	"	3 "	" "	" "	27	0
3	2	10 "	"	5 "	" "	March 2	26	8
4	5	" "	"	3 "	" "	" 3	15	18
5	4	5 "	"	5 "	" "	" "	61	2
6	4	" "	"	3 "	" "	" "	68	26
7	5	10 "	"	5 "	" "	" "	78	5
8	5	" "	"	3 "	" "	" "	111	12

From the above tables we see that there was very little difference

in favor of either form of the cyanide as a killing agent. In all cases the injection at three inches gave better results than at five inches. However, neither form of potassium cyanide gave results that would warrant its use as a soil fumigant in controlling the white grub.

The experiments tend to show that the poison has but small powers of penetration when applied in such a manner. The danger incident upon the application of such a powerful poison under existing labor conditions, would in any case render the advisability of using this substance very doubtful.

Tobacco.

Tobacco is an old-time remedy for insect pests, and although it is only effective when used against delicate soft-bodied insects, frequent attempts were made to control the white grubs with it. The following experiment indicates the average results obtained with this substance. Tobacco water was made by steeping eight ounces of cured tobacco in three gallons of water. It was then applied in pint doses to holes in the soil around the cane stools.

Experiment VII.—Experiment with Tobacco Water Against the White Grub.

No. of plot	No. of stools of cane	Amount applied	How applied	When applied	When examined	No. of grubs found	
						Alive	Dead
1	6	1 pint	Hole in center of stool	March 28	April 2	45	2
2	6	1 "	"	"	"	33	3
3	6	1 "	Hole each side of stool	"	"	45	8
4	6	1 "	"	"	"	42	5

It is readily seen that the tobacco in this form had but very little effect on the white grubs. It is too weak in action and too expensive as well to apply in this manner.

Vaporite.

The last substance to be discussed under the heading of soil fumigants is vaporite, a commercial preparation put out in the form of a gray powder, which on coming into contact with moist soil gradually gives off a vapor. In accordance with directions for the most efficient method of using this material, it should be applied at some depth below the root system of the plant treated so that the vapor given off will kill the grubs and other insets infesting the roots as it rises to the surface.

The following table shows the general trend of all the experiments conducted with this substance:

Experiment VIII.—Experiment with Vaporite Against the White Grubs.

No. of plot	No. of stools of cane	Amount applied per stool	How applied	When applied	When examined	No. of grubs found	
						Alive	Dead
1	2	4 oz.	Hole in center of stool	June 8	June 11	6	0
2	4	2 oz.	"	"	"	8	0
3	6	1 oz.	"	"	"	17	1
4	1	2 oz.	"	May 23	May 27	11	0
5	1	2 oz.	"	"	"	20	0

The above results would tend to show that this substance had no effect whatever on the grubs. It is possible that the material had deteriorated somewhat before application.

SOIL INSECTICIDES AND DETERRENTS.

Under the heading of soil insecticides and deterrents have been grouped experiments with a large number of different chemicals and manurial agents in their relation to the control of the white grub. No special order has been observed in presenting them other than to arrange them as logically as possible.

Experiments with lime and various chemicals and chemical compounds mixed with lime.

Experiment IX.—Experiment with Ammoniac[1] and Lime Against the White Grub.

No. of stool	Amount applied	Mixture used	Depth applied	How applied	No. grubs found after treatment	
					Alive	Dead
1	3 ounces	1/3 Lime 2/3 Ammoniac	6 inches	Each side of stool	8	0
2	" "	"	"	"	5	0
3	4 "	1/2 Lime 1/2 Amoniac	" "	"	1	0
4	" "	"	" "	"	1	2
5	8 "	"	" "	"	7	3
6	" "	"	" "	"	5	1
7	" "	"	" "	Center of stool	6	2
8	" "	"	" "	"	8	2

[1] Sal ammoniac (ammonium chloride).

As may be seen by the above table, the ammoniac and lime had little or no effect on the white grubs.

Experiment X.—Experiment with Carbolineum and Lime Against the White Grub.

No. of plot	No. of stools cane	Amount per stool material used		How applied	When examined	No. of grubs found after treatment	
		Carbolineum	Lime			Alive	Dead
1	5	25 cc.	....	In side of stool.......	3 days later.	27	2
2	5	50 cc.	....	"	"	19	0
3	5	25 cc.	4 oz.	"	"	18	0
4	5	50 cc.	4 oz.	"	"	20	1
5	5	25 cc.	....	Each side of stool....	"	21	1
6	5	50 cc.	....	"	"	6	3
7	5	25 cc.	1 oz.	"	"	2	0
8	5	25 cc.	....	In center of stool....	"	3	0
9	5	50 cc.	....	"	"	24	0
10	5	100 cc.	....	"	"	14	1
11	5	25 cc.	1 oz.	"	"	10	0
12	5	50 cc.	1 oz.	"	"	25	0

The carbolineum, both alone and mixed with lime, had apparently no effect at all upon the grubs as a killing agent. Whether or not it had any value as a deterrent was determined in a field trial together with a number of other chemicals. The results are shown in the following table:

Experiment XI.—Experiment with Lime and Combinations of Lime and Other Chemicals Against the White Grub.

No. of plot	Amount and kind of materials used	No. acres treated	Tons yield per A	Brix	Sucrose	Purity	Available tons sugar per acre	No. grubs found per stool
1	Kreso dip 3 gals. Live lime 300 lbs.	.183	31.83	20.5	17.6	85.9	4.15	10
2	20% carbolic acid 5 gals. Lime 500 lbs.	.275	35.36	19.6	15.4	78.6	4.19	10
3	Carbolineum 5 gals. Lime 500 lbs.	.298	40.86	14.2	9.8	69.0	2.75	11
4	100% carbolic acid 5 gals. Lime 500 lbs.	.298	30.45	19.8	15.9	80.3	3.65	13
5	Live lime 250 lbs.	.138	28.08	19.1	15.3	80.1	3.28	14
6	Check	.275	35.82	19.5	16.7	85.6	4.54	15

The sugar cane used in this experiment was planted in January, 1910, and reaped in April, 1911. The lime and other chemicals were applied May, 1910. As is shown by the table, none of the treated plots did so well as the check plot. Plot 3, although higher in yield per acre, was extraordinarily low in purity, but whether this was due to the treatment received or to some other factor, it is difficult to say.

The fact that more grubs were found per stool in the check plot would suggest that some of the chemicals applied exercised a slight deterrent power, but not sufficient to have any practical value.

Experiments with manurial agents.

To test the value of various fertilizers or manurial agents as deterrents of the white grub an extensive series of experiments was conducted. At first, trials were made on a limited scale with beetles in confinement. Flower-pots containing soil and a small amount of fertilizer were placed in a cage with the beetles. Each pot had a different fertilizer mixed with the soil and the beetles had the opportunity to burrow in the pot that was most attractive to them. In this experiment advantage was taken of the habit of the beetles of hiding in the soil during the day. Examination was made of the pots each day and a count of the beetles in each made. Thus at the end of a week the total number of visits per pot was known and some idea of the repellent or attractive powers of each material could be formed.

After a number of these preliminary trials, an experiment was conducted on a field scale with certain of the manurial agents, to determine their effect on the yield and quality of the cane, as well as their deterrent effect as exhibited over an entire growing season. The results are shown in the tabulations that follow.

In the first experiment nine pots of soil, each containing a small amount of fertilizer, were placed in a cage with fifty beetles. The following table gives the amount and kind of fertilizer in each pot, and the number of beetles that visited each pot daily for a week:

Experiment XII.—Repellant Effect of Various Manurial Agents on May Beetles.

No. of pot	Manurial Agent	Amount used	Number of beetles found in pot on the							Total for week
			1st. day	2nd.	3rd.	4th.	5th.	6th.	7th.	
1	Ammonium Sulphate	1 ounce	6	2	3	9	9	12	17	18
2	Potassium Chloride..	"	2	3	1	0	0	2	2	10
3	Potassium Sulphate..	"	4	5	4	5	1	0	1	23
4	Blood..................	"	9	12	11	3	7	21	17	80
5	Cyanamid............	"	0	0	2	7	2	0	0	11
6	Lime	"	0	0	0	0	11	0	0	11
7	Check	"	16	9	11	4	11	0	5	59
8	Bone meal............	"	9	7	13	13	2	5	1	53
9	Phosphoric Acid.....	"	9	12	5	10	4	10	11	61

In the experiment that follows the same materials were used and in the same proportions. However, in this case ten beetles were placed in each pot and at the end of a week the pots were examined and the living and dead beetles in each counted. Thus some indication of the killing power as well as the repellant action was given.

Experiment XIII.—Repellent and Killing Effect of Various Manurial Agents on May Beetles.

No. of pot	Manurial agent	Amount used	Beetles found at end of week	
			Dead	Alive
1	Ammonium sulphate	1 ounce	35	2
2	Potassium chloride	1 "	3	0
3	Potassium sulphate	1 "	6	0
4	Blood	1 "	3	0
5	Cyanamid	1 "	1	0
6	Lime	1 "	0	0
7	Check	1 "	3	12
8	Bone meal	1 "	10	1
9	Phos. acid	1 "	10	1

From the data given in the two preceding tables the following facts are suggested:

Ammonium sulphate does not act as a repellent but shows good killing powers.

Chloride of potash acts as a good repellent.

Potassium sulphate and acid phosphate do not repel but have some killing action.

Cyanamid and lime are good repellents, whereas blood and bone meal are very attractive to the beetles.

Whether or not these qualities hold up under field conditions may be seen in the data given under Experiment XV.

The following experiment was conducted in the same manner as Experiment XII, with the exception that different chemicals were applied to the soil in the pots.

Experiment XIV.—Repellent Effect of Various Chemicals to May Beetles.

No. of pot	Chemical added	Amount used	Number of beetles found in the pots on						Total
			1st day	2d day	3rd day	4th day	5th day	6th day	
1	Lime 9 pts., sulphur 1	2 ounces	0	12	6	2	0	3	23
2	Carbolic acid ½ %	2 "	0	11	8	19	0	1	39
3	Boiled lime sulphur 2-2-50	1 ounce	0	0	6*	8	1	8	23
4	Self-boiled lime sulphur 2-2-50	1 "	0	7	6	2	9	3	27
5	Caustic soda 1 lb., sulphur 3 lbs., water 50 gals.	1 "	10	0	6	2	1	5	27
6	Filter-press cake	2 ounces	8	2	6	10	6	7	39
7	Kerosene emulsion 1-8	2 "	20	16	6	7	1	6	59
8	Check		12	2	6	0	26	12	58

With the exception of the kerosene emulsion, there was apparently very little difference in the repellent properties of those chemicals. None of them can be considered as first-class repellents. An experiment with the same chemicals to test their killing powers gave such conflicting results that it has not been included in this report.

The following experiment was carried out to test the value of some of the fertilizers previously referred to, when used under field conditions. Plots of one hundred stools of cane were used for each different fertilizer, and at the end of the season the effect on the yield and quality of the cane, and the number of white grubs was determined.

Experiment XV.—Manurial Agents as Deterrents for White Grub.

No. of plot	Manurial agent used	Amount per stool applied	Yield in tons per acre	Brix	Suc.	Gluc.	Pur.	Average 96% sugar per acr. in tons	Average No. grubs per stool
1	Ammonium Sulphate	8 ounces	26.53	19.4	15.3	2.50	79.0	3.15	11
2	Nitrate of Soda.......	4 "	37.22	19.2	15.8	2.38	82.3	4.45	6
3	Cyanamid	1 "	22.57	20.1	15.4	2.38	76.6	2.55	1
4	Muriate of Potash....	" "	25.74	18.7	16.8	2.27	89.8	3.41	8
5	Potassium Sulphate..	" "	22.97	19.7	16.7	2.17	81.8	2.98	10
6	Acid Phos............	" "	29.30	20.1	17.4	1.78	85.3	3.97	10
7	Lime	1 lb.	25.74	20.2	17.3	2.08	81.7	3.48	14
8	Check		26.93	19.6	16.1	2.17	82.1	3.27	10
9	Kainit	4 ounces	28 12	21.0	18.4	1.92	87.6	1.08	7
10	Kainit	8 "	29.30	18.9	15.8	2.27	83.6	3.70	5

From the data presented in the preceding table it is seen that of the materials used cyanamid alone maintained its repellent effect throughout the season. Its effect upon the yield, however, was not good, and the cost of such a treatment, without obtaining a fertilizing compensation to partly offset this cost would make such a practice prohibitive. Further experiments with cyanamid alone have moreover given but poor results and have failed to confirm the results previously obtained.

The nitrate of soda had an excellent effect on the yield and apparently had some slight deterrent power.

Both applications of kainit gave an increase in yield over the check plot and exercised some deterrent effect over the white grubs. None of the fertilizers, however, can be considered as giving results of any very practical value in controlling the white grubs.

Mr. R. H. Van Zwaluwenburg, entomologist of the Federal Experiment Station, has recently carried out a series of four experiments with cyanamid and with cyanamid and acid phosphate, as agents for killing white grubs (*Phyllophaga* spp.) in cane lands. His results are appended herewith.

Summary of Results.

HACIENDA SANTA RITA, GUANICA CENTRALE. APPLIED MARCH 13, 1917; COUNTS MADE APRIL 3, 1917.

	Number of stools	Average grubs per stool
Cyanamid ½ lb. per stool	299	4.1
" 1 " "	91	3.6
No. application (check)	115	3.8

HACIENDA PULIDO, CENTRAL ROCHELAISE, MAYAGÜEZ, P. R., APPLIED OCTOBER 8 TO SIX-MONTHS-PLANT CANE; COUNTS MADE NOVEMBER 23, 1917.

	Number of stools	Average grubs per stool
Cyanamid and acid phosphate 1 lb. per stool	50	3.2
Cyanamid and acid phosphate 2 lbs. per stool	39	3.3
No. application (check)	59	5.1

In this experiment there was so much variation in soil conditions, a ledge of tosca coming out near the surface over much of the field, that not much reliance can be placed on the figures obtained.

At Central Aguirre applications were made in the absence of sufficient grubs to obtain any reliable figures. In one field it was noted that first-instar grubs were present in treated stools, indicating that the eggs are not killed by applications of one pound of cyanamid per stool.

The applications made at Corsica Central were not disturbed. Applications of one pound of cyanamid and one pound of cyanamid and acid phosphate caused no injury at all to young ratoon cane.

Cyanamid alone and cyanamid mixed with an equal weight of acid phosphate are of no practical value against white grubs when applied in amounts up to two pounds to the stool, either when applied as a surface dressing or when worked into the top four inches of soil.

Poison sprays.

Numerous attempts have been made from time to time to kill the beetles by spraying their food plants with arsenical poisons. Since the beetles have biting mouthparts, are hearty feeders and do not fly far, but confine their feeding activities to the immediate vicinity of the cane fields, it seemed highly probable that such methods of control would meet with some success. The arsenicals used in these experiments were arsenate of lead and Paris green. Of the numerous experiments conducted the following four have been selected as being indicative of the results obtained.

Experiment XVI.

Five hundred beetles were caught while feeding on the foliage of young cane. They were placed in a cage and fed for ten days on a common weed, "bleda," (*Amaranthus* spp., a favorite food plant of the beetles), the foliage of which had been sprayed with a solution of arsenate of lead three pounds to fifty gallons of water. At the end of this time the cage was examined and four hundred and sixty-eight of the beetles were found dead while the remaining thirty-two were very sluggish. An analysis of the dead beetles revealed traces of arsenic.

Experiment XVII.

A patch of "bleda" in the vicinity of some cane fields was sprayed with a solution of arsenate of lead of the same strength as that used in the previous experiment. At night five hundred and sixty-five beetles were caught feeding on this poisoned "bleda" and were immediately placed in a cage and fed on fresh, unsprayed material. At the end of a week one hundred and fifteen were found dead, and a week later two hundred more. Analysis showed traces of arsenic.

Experiment XVIII.

This experiment was a repetition of Experiment No. XVI, with the difference that a solution of Paris green was used to poison the "bleda" in place of the arsenate of lead. The solution was made up of one pound Paris green, one hundred and twenty-five gallons of water, twelve and one-half pounds of flour and two and one-half gallons of milk of lime. At the end of ten days an examination revealed two hundred and nineteen dead beetles, two hundred and eighty-one still being alive.

Favorite food plants of the beetles in the fields were sprayed with different strengths of arsenate of lead and Paris green. Beetles were collected at night feeding on these sprayed plants and were kept in cages without food to watch the effect of the poison on them.

Experiment XIX.—Experiment with Arsenate of Lead and Paris Green.

No. of experiment	Host plant used	Poison used	Strength applied	No. beetles collected	Beetles dead after 10 days	Hour of capture
1	Cane...........	Arsenate of lead.	5 ounces, 5 galons	9	0	9 p. m.
2	"	" " " .	3 " 5 "	16	2	9-10 "
3	Casuarina[1]	" " " .	5 " 5 "	35	15	9-45 "
4	"	Paris green	15 grams, 5 "	116	23	9-15 "
5	"	" "	15 " 5 "	6	0	10-30 "
6	Salcilla[2]	" "	15 " 5 "	1	0	10-10 "
7	Casuarina......	" "	30 " 5 "	96	2	9-15 "

[1] *Casuarina equisetifolia.* [2] *Schrankia portoricensis.*

In this experiment the death rate of the beetles was not greater than would be normal with healthy beetles kept without food. It seems probable in this case that the beetles were captured before they had consumed any considerable quantity of the poisoned foliage.

As a result of these experiments it would appear that the spraying of the food plants of the beetles would undoubtedly cause the death of a portion of the beetles; that the working of the poison is slow and that the beetles would probably crawl to their burrows in the soil before dying; and that arsenate of lead is more effective as a poison for the beetles than Paris green. Unfortunately the practice of spraying large fields of cane and the trees in the vicinity of the fields is too expensive to be practical.

MECHANICAL METHODS.

Use of dynamite against the white grubs.

To test the value of dynamite as an agent with which to destroy the white grubs in infested land an experiment was carried out, in which various charges of dynamite were exploded at different depths in the soil and at distances of five feet apart. Previous to the blasting a careful estimate was made of the number of grubs present in the field. Three areas of eight square feet were selected in different parts of the field and a count made of all the grubs found within those areas. By this method it was estimated that there were one hundred and ninety-six thousand and twenty grubs per acre.

Experiment XX.—Experiments with Dynamite Against the White Grub.

Exp. No.	No. of blasts made	Amount dynamite used per charge	Distance between charges	Depth of charge in soil	Diameter of hole made by blast	Soil left untouched by blast	Per cent grubs killed
1	6	1/4 stick	5 feet	8 inches	2 feet	3 feet	52
2	6	1/4 "	" "	16 "	" "	" "	52
3	1	1/2 "	" "	8 "	2 1/2 "	2 1/2 "	72

As may be seen from the chart, best results were obtained by using a charge of one-half stick of dynamite. However, even that amount exploded at distances of five feet apart left one-half the surface of the ground undisturbed, and in the area that was thrown up by the explosion only seventy-two per cent of the grubs were killed. Many of the grubs were thrown out on the surface of the soil without injury. With charges at five feet apart it would have required one thousand seven hundred and forty-two charges per acre, which would have made the cost per acre, exclusive of fuses, caps,

or labor, $239.46. This, of course, made such a practice prohibitive, even had it been successful in destroying the grubs.

Flooding as a method of controlling the white grub.

In localities where there is an abundant supply of water, it was thought possible that by flooding the infested fields for a certain time that the white grubs might be destroyed. To test this theory the following experiments were made.

Several lots of white grubs were submerged in a tank of water for varying lengths of time. They were then taken out and examined.

Experiment XXI.—Effect of Flooding on White Grubs.

No. of Exp.	No. of grubs used	No. of hours kept under water	Per cent of grubs alive after treatment	Per cent of grubs dead after treatment
1	100	2 hours	96	4
2	100	4 "	100	0
3	50	1 "	100	0
4	15	4 "	100	0

In practically all cases the submergence had no other effect than to make the grubs rather sluggish and limp. They soon regained their normal active condition after being exposed to the air. A further experiment was conducted along these lines to determine whether or not a longer submergence would have different results. Several ditches were plugged at each end and filled with water. A large number of white grubs were then placed in the ditches and left for a period of two weeks. The water was then drawn off and the grubs found to be still alive and active. It would seem from the results of these experiments that flooding would be useless as a method of controlling the white grubs.

Use of light to attract beetles.

Knowing that the majority of insects are attracted to light, attempts were made to destroy the beetles by taking advantage of this natural phenomenon. Arc lights and five hundred candle power Pitner gasoline lamps were used in these experiments, and were run through the beetle season from March to November. The lights were erected over large basins filled with molasses and water, so that the beetles attracted to the lights would fall in and be drowned. In the following experiment two of the lights were erected in the midst of cane fields heavily infested with the white grub, while the third was erected on the roof of a two-story building in the vicinity.

Experiment XXII.—Use of Light Against the Beetles.

No. of light	Where located	Kind of light	Time when run	No. of beetles caught	Average No. caught per night
1	In cane field.....	Arc light.........	Nightly from April 20 to May 31	250	6
2	"	"	"	65	1.5
3	On roof of bldg. near cane field	500 c. p. Pitner gasoline lamp	Run for 23[1] evenings in July, Aug., Oct., and November	24	1

[1] On only 7 nights were May beetles taken.

The results of these trials clearly show that little success can be expected with light as a means of attracting the beetles. Since these experiments were conducted it has been found that *Phyllophaga* beetles of the Island are ordinarily attracted to light only during their flight to their food plants in the early part of the evening. The flight only lasts about an hour, and once they have started feeding the beetles are no longer attracted by light. Hence it would be useless to run the lights for more than an hour each night.

Collection of the grubs and beetles.

The most successful method of controlling the white grub that has yet been found is that of collecting the grubs and beetles. The method is rather expensive but it is the only sure way of keeping the pest from increasing.

Some idea of the expense may be obtained from the following figures supplied by Guánica Central, where this method is practiced. During seven months in 1914, a total of 2,255,000 beetles and 1,662,000 grubs were collected at a cost of $2,710.60. The following year 2,468,000 beetles and 2,425,000 grubs were collected at a cost of $3,443.77. More of the grubs and beetles are being collected each year by this central in an endeavor to reduce the numbers of this pest, but unfortunately the method is not very generally practiced by the cane growers of the Island, and in fact the majority of the growers use no method of control whatsoever.

Collections of the grubs should be made when the land is being plowed. Large numbers of the grubs are turned up at this time and should be collected by boys and women following the plows. Where turkeys, chickens, and hogs are available they should be turned into the fields at plowing time, as they will find and devour those grubs that the pickers fail to see.

The beetles feed at night on the foliage of the cane and the trees in the vicinity of the cane fields. They are rather sluggish in their

movements and may be readily captured. Boys and men can go around at night with bags and lanterns and collect the beetles in large numbers by shaking them from their food plants.

The beetles fly during the months of March to November, inclusive, but they are more abundant and hence more easily collected at certain times during this period. These periods of abundance vary somewhat with the locality and it is necessary to watch conditions carefully in order to take advantage of them.

INSECT PARASITES AND FUNGUS DISEASES

In view of the fact that the white grubs of Porto Rico suffer but little from the attacks of insect parasites, attempts were made to introduce some from other parts of the world. Reports on these efforts have been made in other publications of this station, so that no further mention will be made of this work here.

In addition to the introduction of insect parasites attempts were made to utilize a disease of the grubs and beetles known as the green muscardine fungus, *Metarrhizium anisopliae*. A report on this work has been made by Mr. John A Stevenson, pathologist of this Station, and may be found in this number of the *Journal*.

CONCLUSION.

In conclusion it may be stated that control of the white grub is still one of the largest entomological problems of the Island and that undoubtedly a vast amount of work still remains to be carried out. The collecting of the grubs and beetles is at present the only practical method of holding them in check, and it is far from being entirely satisfactory.

It seems likely that the most promising road to success in white-grub control for Porto Rico will be in the introduction of predacious and parasitic enemies.

THE GREEN MUSCARDINE FUNGUS IN PORTO RICO.

(*Metarrhizium anisopliae* [Metsch.] Sorokin.)

By JOHN A. STEVENSON, Pathologist, Insular Experiment Station.

The green muscardine fungus is one of the best-known of the fungi attacking injurious insects, and as such has been studied and observed in many parts of the world. It occurs apparently indigenous in some countries, and has been introduced into various others in an endeavor to make use of it in the fight against insect pests. It is probable that with the exception of the work with *Sporotrichum globuliferum*, an enemy of the chinch bug and other insects, more has been done with this fungus than with any other of a similar nature. Although originally described from Europe, most of the studies upon it and attempts at its artificial dissemination have been made in the tropics or subtropics and in connection with sugar-cane insects.

HISTORY OF THE FUNGUS.

The fungus was first noted and described by Metschnikoff (23)[1] in Russia in 1879 as *Entomophthora anisopliae*. Since that time it has been redescribed under several other names or new combinations.[2] Rorer (29) has given a full account of these nomenclatural details. The combination adopted by him in 1910 has been used by other workers since that time, and is also used in this paper.

Since the original discovery in Russia, *Metarrhizium* has been found occurring naturally in France (6), United States (25), Mexico (40), Trinidad (4, 12), Samoa (8), Philippine Islands (2), Queensland (38), Java (26, 41), Hawaii (16, 17), and Porto Rico. In addition the fungus has been introduced for trial under artificial conditions into Mauritius (5), Java (11, 31), Porto Rico (42), Cuba, and Argentina (7). Cultures from this laboratory have been sent

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[1] Figures in parenthesis refer to literature cited, p. 28.

[2] *Metarrhizium anisopliae* (Metsch.) Sorokin.
Entomophthora anisopliae (Metsch.) (23).
Metarrhizium anisopliae Sorokin (33).
Isaria destructor Metsch. (24).
Oospora destructor Delacroix (6).
Penicillium anisopliae Vuillemin (43).
Septocylindrium suspectum Massee (22).
Chromostylim anisopliae Sorokin (!).
Penicillium anisopliae Vuillemin (43).

to Java and the two latter countries. Speare (34) reports that no introductions were made into Hawaii from Japan or other sources, as far as the available records show, although statements to the contrary have been made.

HISTORY OF THE INTRODUCTION OF METARRHIZIUM INTO PORTO RICO.

The following paragraph from Bulletin 10 of this Station gives the history of the introduction of *Metarrhizium* into Porto Rico:

"*Metarrhizium* was introduced under the name of Hawaiian beetle fungus by D. L. Van Dine, January 12, 1911, and was identified by the writer, whose identification was confirmed by Prof R. Thaxter. * * * This material consisted of infected beetles, some of which were sent to Mr. C. T. Murphy at Guánica Central. More fungus in the form of infected soil was received by Mr. Van Dine, March 30, 1911. On June 3, a letter accompanying material was received at the Sugar Planter's Station" (now the Insular Experiment Station) "from Mr. D. W. May of the Mayagüez Experiment Station. This material was originally from Hawaii."

It was supposed at that time that the fungus was not indigenous, but since then the finding of infected insects in regions distant from the points where the introduced material has been worked with, makes it appear that it did exist in the Island previous to the Hawaiian importations. The native type has at no time been abundant, having been found on single, isolated insects only.

THE FUNGUS.

Although the fungus has been placed at different times in such widely different genera as *Entomophthora*, *Isaria*, *Oospora*, and others, a study of actual material leaves no doubt as to its position near *Penicillium* in the *Moniliaceae*. With one exception, no spore form other than the chains of cylindrical conidia have been reported. Tryon (38) from Queensland makes mention of having found a *Cordyceps* or perfect stage associated with *Metarrhizium*. He assumes the two to be stages of the same fungus, but apparently made no careful cultural studies to prove this assumption, or at least none are given. In as much as no other instances have been recorded, in all of the many references to the subject, of any other spore form such a possibility seems remote. In Porto Rico the fungus has been studied in the laboratory, insectary, and in the field by practically all of the various men who have been connected since 1911 with the

divisions of Pathology and Entomology, and there has never been the slightest evidence to support a theory of another stage in the life history.

Mr. Johnston (14) records two conidial forms, forma *major* and forma *minor* occurring on different hosts. Sufficiently complete accounts of the appearance and behavior of the fungus on artificial media as well as technical descriptions will be found in several of the articles cited in the bibliography, in particular those by Rorer (29), Speare (35), Johnston (14), and the earlier papers by Metschinkoff (23, 24).

HOSTS.

The number of species of insects attacked is very large, and includes many that are of considerable economic importance. A list of the more important host species, together with the country from which the report was made, follows:

Adoretus compressus, Java (41).
Adoretus tenuimaculatus, Hawaii (16–18).
Adoretus umbrosus, Hawaii (35).
Agriotis manci, New York (25).
Anisoplia austriaca, Russia (22).
Anomala, sp., Hawaii (35).
Cleonus punctiventris, Russia (32).
Cyrtacanthracris nigricornis, Java (31).
Holotrichia helleri, Java (11).
Lachnosterna sp., Illinois, reported by Wolcott.
Lepidiota albohirta, Queensland (38).
Leucophilus rorida, Java (31).
Oryctes rhinoceros, Samoa (8).
Phytalus smithi Mauritius, (?) (5).
Rhabdocnemis obscura, Hawaii (29).
Tomaspis postica, Mexico (40).
Tomaspis varia, Trinidad (9, 28).

It will be noted that this series includes the froghopper of Trinidad, as well as a number of other serious cane pests: the rhinoceros beetle, a pest of the coconut: the cockchafer of Europe, and other well-known depredators. The silk-worm has also been reported as a host by Delacroix in France (6).

A considerable range of hosts has also been found in Porto Rico but for the most part only insects in confinement in the breeding cages. These have been collected by the several entomologists of

the Station, but more particularly by Mr. E. G. Smyth (32) who carried on work with the white grubs over a number of years.

The insects found diseased by *Metarrhizium* in Porto Rico are as follows:

Aphodius sp.
Canthon sp.
Dyscinetus barbatus.
Lygyrus tumulosus.
Metamasius hemipterus.
Phyllophaga citri.
Phyllophaga guanicensis.
Phyllophaga portoricensis.
Phyllophaga vandinei.
Phytalus insularis.
Strategus titanus.
Tiphia inornata. (Received from Illinois.)

The fungus has been found in addition on a number of undetermined Scarabaeids, an earwig, a roach, and some other unnamed hosts. The localities of the many collections made have been Río Piedras (Experiment Station), Santa Rita (Guánica), and Añasco, localities into which the fungus was introduced Specimens have also been taken at Fajardo (*Phyllophaga* sp.), Hacienda Santa Isabel of Aguirre (*Phyllophaga* sp.), and Sierra de Naguabo (earwig), localities into which the fungus was not introduced, apparently tending to prove that the fungus is indigenous to the Island.

Further information on the stages of the various hosts attacked, prevalence, progress of the disease on the individual insects, and related points will be found in the report by Smyth (32).

EXPERIMENTS IN ARTIFICIAL DISSEMINATION.

Metschnikoff (23) conducted the first experiment with *Metarrhizium*, using it to fight the cockchafer of wheat. He obtained his spore material from infected insects. Krassilstchik (19, 20) used the fungus in a similar fashion in this work on the sugar beet curculio and reported from fifty to eighty per cent of the insects infected. These earlier experiments were necessarily on a limited scale because of the difficulty of obtaining spore material in quantity.

During recent years extensive tests have been carried out in Java, Hawaii, Trinidad, Porto Rico, and other regions.

The most important of the efforts in this connection has been Rorer's (27–29) work in Trinidad directed against the froghopper

(*Tomaspis varia*). Entomologists and others (1, 3, 4, 9, 10, 13, 39) connected with the agricultural work of that Island have also assisted in the tests. In the preliminary experiments adult froghoppers in wire cages were inoculated by spraying, and a high percentage of mortality resulted. Results were also obtained in infecting the nymphs. A field experiment, using a mixture of flour and spores, in which over one hundred cane plants were dusted, resulted very favorably in the death by the fungus of a large number of the insects.

Work was then commenced on the production of spore material in great quantities so as to permit of the dusting or spraying with spores of entire fields. For this purpose large cabinets capable of being sterilized by steam were devised. The manner of construction of these cabinets and the course of procedure in producing the spore material have been fully described by Rorer. The results obtained were sufficient to cause these spore-producing plants to be erected on a number of the sugar estates. These are operated at such times as conditions seem favorable for rapid increase of the froghoppers.

The experiments in Java have been carried on in several sections of the Island by different workers but have all been confined to tests on a small scale, mostly in breeding cages apparently. Groenewege (11) infected soil with the spores and then added larvæ of various insects, varied proportions of which were killed by the fungus. He concludes that since most of them were killed near the close of the larval period, and after the full damage to the host would have been caused, that the method is not efficacious. He furthermore stated that the cost would be prohibitive for field operations.

Rutgers (31) carried out experiments at practically the same time, using cultures obtained from Hawaii. For infection he employed spores mixed with a double quantity of flour. The insects used were *Leucophilus rorida* and locusts (*Cyrtacanthacris nigricornis*). In one experiment a mortality of eighty per cent was obtained, but succeeding tests gave only slight results. It was found that infection, even when the insects were enclosed in a small space and were in intimate contact with quantities of spores, was dependent upon external conditions, particularly the moisture content of the air. For this reason and since *Metarrhizium* is found under natural conditions attacking a wide range of insects he concluded that it is a dangerous parasite only under favorable conditions, and that attempts to spread the fungus artificially would be useless.

Speare (35) in Hawaii carried out an extensive series of laboratory inoculations with the fungus, working with *Rhabdocnemis obscura* as the host. The mortality varied considerably in the different trials, not exceeding sixty per cent, however, in any case. No field tests are reported.

Tryon (38) has also conducted tests upon the parasitism of *Metarrhizium*, using the spores mixed with a fine soil rich in organic matter. Final results and conclusions are not given beyond the statement that the fungus appears to have possibilities.

In Samoa (8) excellent results were reported in controlling on an extensive scale the rhinoceros beetle, an enemy of the coconut. Infected beetles were placed in trap piles of rotten coconut husks and other debris, scattered about through the coconut groves. The beetles gathered in these piles for egg laying, and it was claimed that practically all the larvæ were ultimately attacked and killed by the fungus.

Porto Rico.

Work with this fungus was begun immediately upon the receipt of material from Hawaii. Infected beetles and soil containing spores were sent to Mr. C. T. Murphy in charge of experimental work at Central Guánica. In June, 1911, he reported as follows: "The Hawaiian beetle fungus seems to be working well and the beetles kept under control in the cages seem to take it up rapidly At present several thousand are under control and in a few days time, I shall start letting them loose in the fields * * *. I am also propagating the spores artificially so as to more thoroughly infect the beetles." About a year later (April, 1912) he reports that "Inoculating beetles with the Hawaiian fungus started earlier in the month. The fungus took readily and appears to be increasing in virulence; about a fortnight after inoculating the cage, eighty-seven beetles were found killed by the disease. During the next month liberations of dead and sickly beetles will be made about every ten days in a field where the work can be watched."

Mr. Murphy stated that in May he found evidence of beetles having been killed by the disease, and in July a final mention of Metarrhizium occurs in his reports to the effect that "Beetles infected with the Hawaiian fungus have been liberated during the month in cane fields, and at the roots of trees around the nursery

beetles killed by the fungus have been buried so as to infect the soil." It is not apparent that any practical results came from this work.

At the Experiment Station at Río Piedras in connection with cultural studies of the fungus Mr. Johnston, then pathologist, carried on in 1912 a series of inoculation tests in screened cages. Beetles and larvæ (*Phyllophaga vandinei* for the most part) were obtained from the vicinity of Añasco, and Santa Rita, Guánica. These were stored in three cages until transferred to the inoculating cages. It may be noted that ten beetles were found infected in these supply cages as the transfer was being made, pointing again to the natural occurrence of the fungus.

In addition to the *Metarrhizium* trials, other entomogenous fungi secured from France were used in a similar fashion. These were *Sterigmatocystis ferrugineus*, *Sporotrichum globuliferum*, *Isaria densa*, and *Botrytis Bassiana*. No positive results were obtained with these, but on the other hand the beetles in each of the boxes in which these fungi were employed showed infection with *Metarrhizium*, as will be noted hereafter.

The *Metarrhizium* material used was a transfer from an isolation made from infected insects received from Hawaii. In each case the fungus material was scraped off the surface of the medium (yam cylinders) and placed with distilled water in an atomizer. The surface of each box was thoroughly sprayed with the spore suspension, and the culture medium itself placed on the surface of the soil. The beetles were then added from the supply boxes and observations taken from time to time. All beetles found dead were held for full development of any fungus that might be present, so as to permit of exact determinations.

As the results obtained were much the same for all, details of the examination of but one box are given, as per the following table:

Infection of May-Beetles by *Metarrhizium* (Box No. 1).

Date	May 21	June 1	6	10	15	21	26	July 1	8
Dead on surface.	1			6		5	2		
Infected.........						1			
Dead in soil.....	9	18	17	16	7	9	3	5	2
Infected.........	5	8	8	6	3	3	1	2	1

Total dead, 100; infected by *Metarrhizium*, 38.

A Summary of results from all the boxes follows:

Infection of May-Beetles by *Metarrhizium*.

Box No.	Inoculated with	No. of beetles dead	No. infected with *Metarrhizium*	Per cent infection
1	Metarrhizium......	100	38	38
2	"	113	22	19
3	Sterigmatocystis.....	98	35	35
4	Sporotrichum........	102	18	17
5	Check..........	97	29	29
6	Supply........... ...	678	93	14
7	Isaria	92	31	33
8	Botrytis........	101	29	27
9	Supply	1132	190	16

It can very clearly be seen from these results that the fungus was, first of all, not especially virulent toward the May-beetles and that above all it occurred independent of inoculatons.

In order that thorough field trials might be carried out, there was constructed at the Station an apparatus (see Fig. 1) consisting of two cabinets and a five-horse-power upright boiler, following the plans of Rorer (27, 30). The medium used was rice, spread out in thin layers on the shelves and cooked *in situ*. No particular difficulties other than mechanical ones were encountered, and the first batch of spore material was taken off by Mr. Johnston in August, 1913. A low-grade flour was used to dilute the spore mass and to make removal from the rice media more easy.

The resulting material consisting of about fifty pounds of the flour-spore mixture and a similar amount of the rice residue was taken to Yauco on the south coast, and applied to one of the fields of the Guánica Central. About an acre of young plant cane was dusted, using two types of hand dusters, the Furet and the Cyclone. The former was the more convenient and serviceable. The rice residue material was applied by hand around stools of cane adjoining the dusted area.

In October a considerable number of adults were collected from the dusted area by Mr. Smyth and confined to Santa Rita. Only one of the entire number showed at any time signs of *Metarrhizium*.

The following year another lot of spore material was prepared by the writer and again applied to the field previously dusted at Yauco and in the same manner. It has never been apparent that any infection resulted among the beetles in this field. A third lot

of material was some months later applied at Río Piedras not only to cane, but around the bases of a number of coconut trees, which had been severely attacked by *Phyllophaga* sp. Infected insects have never been recovered.

CONCLUSIONS.

As a result of the field observations and the varied experiments carried out by the members of the Station staff and others who have been connected with the project, the conclusion seems justified that the green muscardine will not serve as a practical means of controlling the white grubs or May-beetles in Porto Rico.

It is true that in confinement various stages of *Phyllophaga* spp. are subject to attack, as are also other cane pests, but even in these instances the disease has not been virulently parasitic. No positive results have been obtained in the field tests and it appears that the fungus is indigenous, but so dependent upon humidity and other natural conditions that it is a negligible factor in controlling insect pests and will remain so.

This conclusion is borne out by the reports of workers in Java, both Rutgers (31) and Groenewege (11) stating that while considerable numbers of insects were attacked in confinement, results in the field were so absolutely dependent upon the weather that no artificial attempts at dissemination of the disease would avail. The favorable results obtained in Samoa in the control of the coconut beetle may be easily accounted for by the fact that conditions approximated confinement, the piles of debris retaining moisture, so that for all practical purposes they were no different than so many insect cages. None of the Porto Rican insects lend themselves to this method of trapping.

In Trinidad most favorable results have been reported, it is true but in this case the insect pest involved has an entirely different mode of life from the May-beetles, which it is thought will account for the difference in the efficiency of the fungus in the two regions. It is also quite possible that the weather conditions prevailing at times of severe froghopper infection may favor the fungus.

It does not seem advisable to carry out any further work with the green muscardine in Porto Rico, at least in connection with the white-grubs or May-beetles.

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PLATE I.

THE GREEN MUSCARDINE FUNGUS IN PORTO RICO.

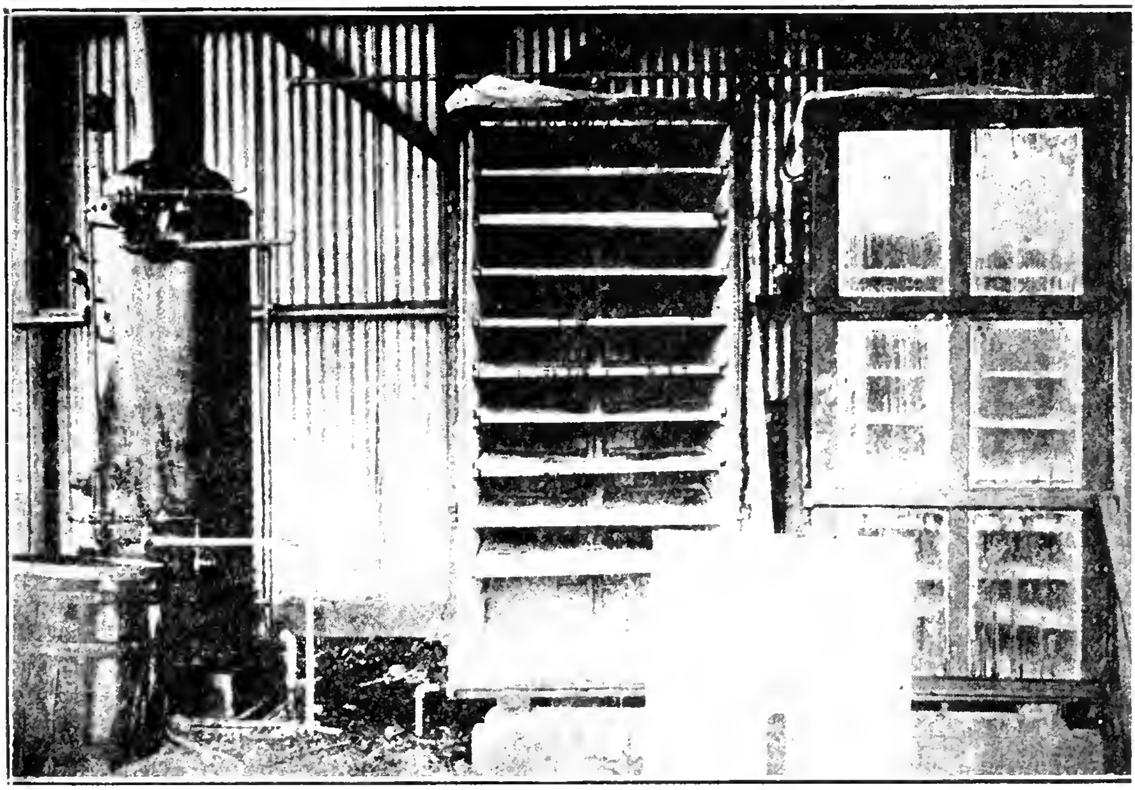

FIG. 1.

FIG. 2.

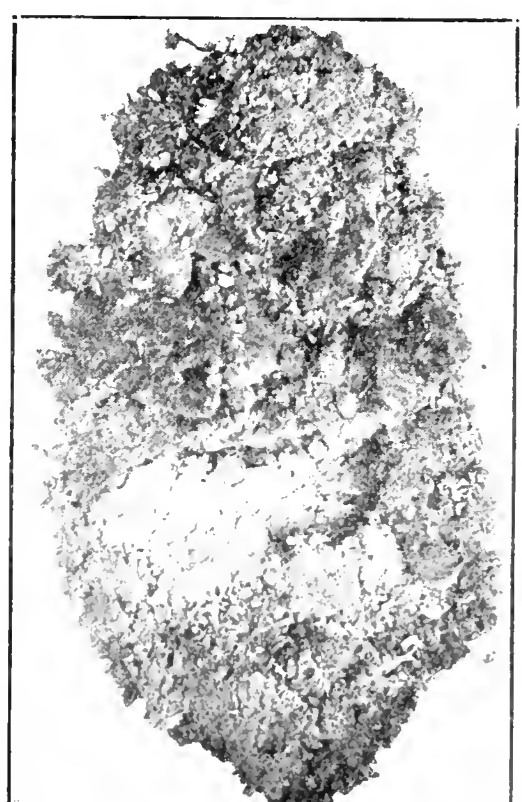

FIG. 3.

EXPLANATION OF PLATE I.

Fig. 1.—Cabinets used in the production of *Metarrhizium* spore material, and boiler, the source of the steam supply.

Fig. 2.—Pupa of *Ligyrus tumulosus* infected with *Metarrhizium*, showing also molted larval skin.

Fig. 3.—Pupa of *Strategus titanus* infected with *Metarrhizium*, showing characteristic conidial masses.

Figs. 2 and 3 from photographs by Smyth.

STUDIES IN INHERITANCE IN SUGAR CANE.

By H. B. Cowgill, Plant Breeder, Insular Experiment Station.

INTRODUCTION.

Although only a few experiments have been conducted in the breeding work with sugar cane at this Station, for the sole purpose of studying inheritance and related subjects, it has been the purpose, as the work progressed, to secure as many useful data as possible from the seedlings which were being propagated and selected. Points which are of interest are the extent to which characters are inherited from the parent varieties when the latter are self-pollinated; whether new types are produced in the nature of mutations; and in what manner and to what degree varieties can be expected to transmit their characters to seedlings when crossed. Various cane varieties have been tried as seed-producers, and it has become evident that, in general, when cross-pollination has not been attempted, there is clearly a difference in the appearance and apparent value of seedlings produced from the different varieties, and that there is also considerable difference in the amount of resemblance to the parent varieties. In many cases this resemblance is plain, and in others there is very little similarity. The reason for this may be that all cane varieties are probably more or less heterozygous, the cases of closer resemblance being due to more homozygous parentage. It is also possible that accidental intercrossing sometimes takes place between varieties growing in the same locality, and that this affects the appearance of the resulting seedlings. Resemblance to both parents has also been observed, when cross-pollination has been affected between varieties, and it is worthy of note that in some cases similarity to the pollinating parent is very plain.

SEEDLINGS SHOWING RESEMBLANCE TO SEED PARENT.[1]

A very close resemblance of seedlings to parent cane, as to visual characters, has been observed every year since 1913 in seedlings pro-

[1] For descriptions of cane varieties see "A Method of Identification and Description of Sugar Cane Varieties and its Application to Types Grown in Porto Rico": H. B. Cowgill, Plant Breeder, Insular Experiment Station, Porto Rico; Journal of the Department of Agriculture, Vol. 1, No. 3, July, 1917.

duced from seed of D–109.[1] This is a dark greenish-red to purple cane, usually reclining in habit, with buds before expanding semi-elliptical in shape. Many of the seedlings plainly show some or all of these characteristics, while the resemblance as to color is especially noticeable.

A great majority of the seedlings of T–77 are very much like this variety in color and habit, and resemble it more or less as to the form of the bud.

Out of thirty-four seedlings produced in 1916 from B–347, a light-colored cane, only two were of a darker shade than the parent, and seventeen of them showed spots on the internodes more or less like the characteristic spots on the parent variety.

The B–109 seedlings produced in 1916, one hundred and ninety-two in all, were all yellowish-green in color, being like the parent variety in this respect. They also resembled the parent more or less as to the shape of the internodes and the buds. One seedling was darker green than the parent variety and had a tinge of red on the upper internodes; one was a shade darker green, but without the reddish tint; three were greenish-yellow like the parent, but tinged with red on the upper internodes; three were the same color as the parent with the addition of brownish-red blotches on the stalks.

Other variations occurred among these seedlings as follows. Two were markedly glaucous; one had especially prominent buds; one had extremely short joints; two had many adventitious roots; one had especially thin stalks; one was very thick-stalked. There was also a great difference among these seedling as to vigor of growth. Those growing in the area of better soil were taller and of larger girth, while a majority of those on poorer soil appeared more or less stunted, some of them producing almost no stalks.

Out of three hundred and sixty-six seedlings from the variety D–448, which is a red cane, two hundred and twenty-one or sixty per cent, showed redness on the stalk, though some in a less degree than the parent variety. Thirty-four per cent were red all over the stalk, but some were a lighter red than the parent cane. Twelve per cent were as dark or darker than the parent.

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[1] These seedlings and those of subsequent instances cited, except where cross-pollination is indicated, were raised from seed from open-pollinated tassels. For that reason the purity of the pollen can not be guaranteed. However, it does not seem probable that sugar-cane pollen is carried more than a short distance by the wind. It has no special adaptation for being transported and is soft and delicate. In some cases observed the stigmas of the florets were in close contact with the dehiscing anthers. The anthers are shed in great numbers, and possibly they pollinate other florets as they fall. For these reasons it seems probable that the tassels in the center of a field of a pure variety are, without exception, pollinated by pollen of the same variety. The similarity of the seedlings in many cases also tends to verify this belief. It is planned to bag tassels for self-ollination to obtain further data on this point.

Among these seedlings two non-glaucous wine-colored canes occurred; two were greenish-yellow; two were reddish-green and glaucous; three were light reddish-green and glaucous; one had distinctly tumid joints.

All seedlings produced from D-117 seed have shown marked resemblance to this variety in color and in habit of growth, but they have shown more variation in the type of the internode and the bud. Abnormalities such as dwarfed canes, extremely short internodes, wedge-shaped internodes, and buds of unusual form have been common. In using the term abnormality the writer includes only stools distinctly different from the varieties cultivated for commercial purposes, and especially those unfit for commercial cultivation.

Approximately nine hundred D-117 seedlings were grown to maturity in 1916-17. In color they were almost uniformly like the parent variety. No dark-colored canes whatever were found among them. One seedling only out of this number was a slightly different color, being green instead of yellowish-green. The most marked variations were in length of stalk and length of internode. Some of the stools were reclining in habit, but most of them were as erect-growing as the parent variety.

In all, twenty-four abnormal stools were found among these seedlings.[1] Nine of them were classified as "dwarfs." They had stalks not over three feet long and almost uniform in length; internodes one-half to one inch long; usually semi-prominent buds; erect-growing leaves; and often few or many shoots growing from the base of the stool. Some of the abnormal cepas were similar to the dwarfs, but had one or more long stalks.

Other unusual characters in these abnormal canes were stalks with all or many of the buds sprouted, and stalks with many adventitious roots. Still other unusual characters, especially among the dwarfs, were the presence of dead stalks in the stools and a tendency for the entire stool to have withered or weak tops. Some stools also had stalks with wedge-shaped internodes, each averaging about an inch long on one side of the stalk, and narrowed down to sometimes practically nothing on the opposite side. It is planned to grow some of these variations to see whether the abnormal characters are inherited.

[1] It might be assumed that the unusual types which are found among cane seedlings are due to characters acquired by intercrossing of various types of cane at an early stage in the development of the species, and that these characters have been hidden by reason of the dominance of others, since cane has been propagated by sexual means for an unknown period of time. But the question also presents itself whether such abnormalities are not of the character of mutations, and whether some of the other variations in cane seedlings may not also belong to the same class.

RESEMBLANCE OF SEEDLINGS TO PARENTS IN CANES FROM CROSS-POLLINATED TASSELS.

Seedlings produced from tassels of Crystallina cane, which had been bagged and pollinated by D–109 in 1916, showed resemblances to both parent varieties. Some of them were almost identical in appearance with the pollinating variety, while a few closely resembled Crystallina. Between these two types many variations could be found.

The method followed in crossing is described in the Fourth Annual Report of this Experiment Station.[1] A bag of closely-woven cheese-cloth is supported by means of a bamboo pole over a tassel of a variety which is, for practical purposes, pollen-sterile. Cut tassels of the variety which is to furnish the pollen are tied in position inside the bag, so that the wind will carry the pollen, as it is shed, to the stigmas of the tassels of the other variety. This method has proven very satisfactory for our purposes, as a large number of crossed seedlings are produced, and there is very little possibility of any pollen fertilizing the ovaries of the female parent tassel except that from the tassels introduced into the bags, or occasionally that from its own anthers. If the variety used for a pollinator happens to be a dark-colored cane and the other lighter colored, as was the case in this cross, it is then possible to observe many seedlings which show this character of the male parent. There is then little possibility of doubt but that they are the result of cross-pollination. Where the parents are not so distinctly different it is impossible to be absolutely certain whether individual seedlings are from cross-pollination or from self-pollination of the variety intended for the seed parent. The progeny taken as a whole, however, can be considered largely cross-pollinated seedlings.

The canes resulting from cross-pollination last year have grown well and many of them appear promising for commercial culture. Only one abnormal stool was found among them. This was a very small stool, the stalks being only about one-fourth inch to one-half inch in diameter and proportionately short. The leaves were also relatively small. Except for its size this cane was quite like D–109, the variety used as a pollinator.

The following types were observed among these seedlings:

1. Typical D–109.
2. Typical Crystallina.

[1]Fourth Annual Report, Board of Commissioners of Agriculture of Porto Rico, pp. 22–33, 1914–15.

3. Like D–109 as to color but with internodes and buds like Crystallina.
4. Like D–109 in shape of internodes and buds, but of a lighter color and very glaucous.
5. Canes greenish-red to wine color, very little glaucousness, with buds more resembling those of Crystallina than D–109, and with internodes intermediate between the two.
6. With internodes like those of D–109, color like Crystallina, but larger in diameter than either.
7. With internodes and buds like Crystallina, but the color darker and somewhat like that of D–109.
8. Like D–109 as to internodes and buds, but like Crystallina in color.
9. Like D–109 in color but with large nodes, constricted internodes and with buds somewhat like those of Crystallina.
10. Like Crystallina as to buds and internodes but more glaucous.

The following data concerning these canes were also noted:

	Number.	Per cent.
Total stools	560	100
Stools as red as D–109	147	28.3
Stools darker than Crystallina	294	52.5
Stools having internodes like D–109	246	43.9
Stools having no character like D–109, and with color and internodes like Crystallina	42	7.5

These observations were made when the canes were quite mature, so that there was the least possible chance of subsequent change in appearance; but cane varieties are extremely variable and their appearance is affected in many ways by outside influences, such as soil conditions, moisture and sun-light, so that it is difficult to separate different types. Should varieties still more distinctly different be chosen for crossing, more definite results would possibly be secured in the resulting seedlings. The above data, however, show certain points which are worthy of note. They indicate that there is a form of combination of characters in some, at least, of the seedlings resulting from a cross between two varieties of cane. This may be due to certain characters derived from each parent variety, being dominant in the heterozygous seedlings. It also appears that there is greater variation in seedlings so produced, than in those obtained from tassels not cross-pollinated.

As to the economic value of the seedlings produced by crossing,

there is little to be said at present. Many produced by this cross appear very promising, and a relatively large number were selected for extension and further trial, although their true value will not be definitely known until they have been tested further.

Available data as to the sucrose content of the juice of three of the groups of seedlings under consideration, as well as of two other groups which were germinated in 1912, are given here. The distribution is in classes which differ by one per cent, grouped on the nearest half per cent.

Per Cent Sucrose in Juice of Seedlings of Different Parentage Groups.

	9.5	10.5	11.5	12.5	13.5	14.5	15.5	16.5	17.5	18.5	19.5	20.5	Totals	Mean	Standard Deviation	Coefficient of variability
1912																
Otaheite parentage ..	..	..	..	..	2	2	0	3	4	1	6	2	23	17.72 ± .292	2.06 ± .206	11.6 ± 1.168
D—117 " ..	..	..	1	2	6	9	19	21	21	5	3	..	87	16.23 ± .117	1.62 ± .083	9.9 ± .510
1916																
D—118 parentage ..	1	1	0	0	3	1	6	11	8	1	..	..	38	15.97 ± .215	1.97 ± .152	12.4 ± .959
D—117 " ..	..	..	1	1	5	5	8	2	2	..	..	..	24	11.81 ± .196	1.13 ± .139	9.6 ± .934
Crys. × D—109 parentage ..	1	2	0	2	6	9	8	13	7	..	..	..	48	15.16 ± .181	1.89 ± .130	12.5 ± .873

There are some differences shown in the frequency distributions of these populations; however, seedling canes are very much affected by environmental influences, and no data are at hand to show that frequency distributions of subsequent generations of such groups would show the same relation as that shown here. Moreover, it is the individual seedlings that are of interest, as new varieties are formed by asexual multiplication of these; and even though we assume the above to be the case, we still cannot say that the chances of selecting superior seedlings are greater in a percentage group showing a relatively high frequency distribution, than a low one, until it is shown that the individual ranges of variation of subsequent generations of the separate seedlings of these groups bear a relation corresponding to that of these first generation seedlings. The coefficients of variability of these groups of seedlings range from 9.6 ± .934 of the D–117 parentage group of 1916, to 12.5 ± .873 of the Crystallina × D–109 parentage group, the latter being a little greater than that of the D–448 parentage group, which was 12.4 ± .959. Statistics of different years are probably not comparable, though it is notable that the coefficient of variability of the D–117 canes was the same for both years. In both years the coefficient of variability of the D–117 canes was the smallest, and in the 1916 seedlings those of D–448 and Crystallina × D–109 were about the same. The number of individuals in any group is not sufficiently large, and the data at hand are not sufficient to allow conclusions to be drawn. The table is included with the other data at hand at this time, mainly for the purpose of pointing out a line of work which may give results when it has been completed.

CONCLUSIONS.

1. Seedling sugar canes in their first generation show a degree of resemblance to the varieties from which they were produced.

2. The results of the work at this Station indicate that resemblance of color is more marked than that of any other characteristic.

3. There is wider variation in seedlings than in canes produced from cuttings of the same variety.

4. The greatest variation in seedlings produced from tassels of a single variety is in the size and form of the plants, and of their component parts.

5. Certain varieties, produce better seedlings than others.

6. Abnormalities are common in seedling canes, whereas in canes

produced from cuttings they are rare. Certain varieties produce many more abnormal seedlings than others.

7. New types of cane are produced by crossing varieties.

8. Variation is apparently increased by a single combination of two varieties.

9. Crossing seems to produce a recombination of characters of the parents in some of the resulting seedlings, this probably being due in a measure, to dominance of certain characters derived from each parent.

10. Only slight differences in sugar content of the juice have been observed between groups of seedlings produced from different varieties.

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OF

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Citrus diseases of Porto Rico .... JOHN A. STEVENSON.

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CITRUS DISEASES OF PORTO RICO.[1]

By JOHN A. STEVENSON, Pathologist, Insular Experiment Station.

INTRODUCTION.

The citrus industry in Porto Rico, in so far as the production of fruit for export is concerned, dates from about 1902, and for a number of years was confined to orange growing almost exclusively, grapefruit production not having reached a figure of any importance until 1907. The early exportations were from seedling trees growing in groups, or as scattered specimens through the upland coffee districts of the Island, where they were used to a considerable extent for shading the coffee, fruit production being a secondary consideration. Limes and lemons existed as individual trees for a home supply only, and the grapefruit was practically unknown.

Once initiated, the planting of citrus groves, for the most part limited to several varieties of oranges, was taken up rapidly, and before many years extensive groves were in existence along the north coast between Carolina and Arecibo. For a number of years attention was concentrated on the orange, but the grapefruit rapidly came into favor, so that for the past few years practically nothing but the latter fruit has been set in new groves, or extensions of old ones.

Moreover, the practice of budding over orange to grapefruit has been common, so that at the present time the production of grape-

[1] This paper is based on the work carried on by the writer as part of his official duties over a period of nearly four years. Acknowledgment is made of assistance received to Mr. R. C. Rose, assistant pathologist now on leave for war service; to Mr. W. V. Tower, formerly director, for encouragement at all times; to the citrus growers of the Island who have shown all possible courtesies in the course of the field work; and to the Porto Rico Fruit Exchange, which has given most substantial assistance to the project.

In order that the greatest possible amount of information on the various diseases might be presented to the growers, the publications of the experiment stations of Florida and California, and of the United States Department of Agriculture, as well as other sources, have been drawn upon, where the matter contained was applicable to local conditions.

fruit greatly exceeds that of cultivated oranges. The continued heavy marketing of the so-called wild oranges will explain the large total of the orange exports. The basic reason for the change from orange to grapefruit in the cultivated groves has been economic, better returns at lower cost of production having been realized from the latter fruit in the opinion of most growers.

The progress of the industry, and the relative importance of the two fruits is graphically shown by the following table, which gives the value of the exports from 1901 to date:

Value of Exports of Citrus Fruit from Porto Rico.[1]

Year	Orange	Grapefruit
1901	$84,475	....
1902	51,364	....
1903	230,821	....
1904	352,646	....
1905	125,422	....
1906	295,63[illegible]	....
1907	469,312	$7,586
1908	630,720	44,535
1909	401,912	76,310
1910	582,716	162,749
1911	703,969	309,698
1912	584,414	525,048
1913	740,091	762,811
1914	752,180	751,769
1915	378,181	834,440
1916	790,797	837,014
1917	1,009,737	939,677

[1] From Report of the Governor of Porto Rico, 1917.

Limes, lemons, or citrus varieties other than oranges and grapefruit, have, as already noted, never been grown on any extensive scale, the trees being limited for the most part to individual specimens for domestic purposes only. At no time have shipments been sufficient to warrant separate statistics.

In the early years of the industry, lemon culture was tried by a number of growers, and some quite extensive groves were set out, but on the north coast at least no success was attained. This was due to the ravages of foot-rot and scab, and to cultural conditions, lemon growing requiring considerable skill. The growing of this fruit could beyond much doubt be carried out most successfully in the irrigated sections of the south coast by anyone possessing the requisite knowledge.

Progress of disease investigations.

It has been true, most unfortunately, that along with the rapid development of the citrus industry certain diseases, several of them very severe, have made their appearance. As early as 1901 the presence of scab was mentioned in the first report of the Mayagüez Experiment Station, and in several succeeding reports, particularly those for 1903, 1904, 1909 and 1913, reference was made to this and other citrus diseases.

Investigations commenced in 1915 by this Experiment Station, revealed that for a considerable period the groves had been suffering from the attacks of certain diseases, particularly scab and foot-rot. The first disease to assume importance was foot-rot, which for a time took on an epidemic character, but had by 1914 practically subsided as a result of the use of resistent stocks and improved cultural methods.

The situation with regard to fruit rots or shipping rots became so serious that in 1913 help was asked of the United States Department of Agriculture. Observations were made of the condition of the fruit as it appeared on arrival at New York, and the fungi involved were studied in the laboratories at Washington. Mr. C. W. Mann, of the Bureau of Plant Industry, was sent to the Island and made a tour of the citrus-growing sections to investigate the status of affairs here. The report of his work has been published as Bulletin No. 7 of this Station.

Since about 1913, the scab situation has been serious, the bulk of the fruit of some growers commonly being so badly disfigured as to be unsalable, excepts as culls. Other diseases, of minor importance in themselves, have in the aggregate produced no inconsiderable losses.

It is impossible to arrive with any degree of accuracy, at the total loss to be charged to diseases, so many separate items composing the whole, and this being in turn so intimately connected with the damage to be charged to insect pests and mechanical injuries. Then again, the loss from many diseases—for example, die back or bark rot, which lessen the crop production over a series of years, or may even destroy a tree—cannot be figured on any definite basis.

A very rough estimate, but at the same time a most conservative one, will place the annual financial loss suffered by the growers and to be charged to the various diseases including shipping rot, at five per cent of the crop, or approximately $100,000. In the case of

the wild orange crop this estimate is very low, the loss from shipping rots alone commonly amounting to ten per cent. and often going as high as fifty.

The need for investigation of the citrus diseases was recognized, and immediate attention given, following the turning over of the present Insular Experiment Station to the Government by the Sugar Producers' Association. Progress reports and publications have been issued from time to time on certain phases of the problems investigated. These are noted in the bibliography on page 110.

As the work has progressed it has become apparent that, considering the groves as a whole, there is taking place a gradual spread of the various diseases, and that certain ones are becoming more virulent. Several have been discovered of comparatively recent introduction, or at least of recent activity on citrus hosts, and these may at any time assume a virulent state. The increased plantings, for the most part of one species, the grapefruit, and often in practically continuous stretches, tend to favor the increase and spread of injurious fungi.

The entire subject then, and particularly the matter of control measures from the grower's view point, becomes increasingly important. Many who have in the past ignored or given scant attention to the matter of grove sanitation, spraying, and improved cultural conditions, are now confronted with the vital necessity of prompt action along these lines.

While much has been accomplished in disease control in other citrus-producing regions, we find that recommendations applicable there often fail to give results under Porto Rican conditions, and it becomes clear that our disease problems must be worked out in large part here. The life histories of the various fungi involved and the principles of control can be studied out in the laboratories, or in such field experiments as are possible, but the practical working out of control measures lies very largely in the grower's own hands.

Citrus diseases not present in Porto Rico.

Although Porto Rico has an all-too-long list of diseases present in the groves, there are still a considerable number of diseases, recorded as serious, which exist in other parts of the world and have not yet reached the Island.

Probably the best known of these at the present time is the canker, a most virulent bacterial disease of leaves, fruits, and young twigs, which was accidently introduced from Japan into a number of the Southern States some years ago. Several millions of dollars have

been expended in the attempt to eradicate it, and the fight has not been concluded.

Among other diseases which can be mentioned in this connection are the brown rot (*Pythiacystis*), which caused enormous losses to the California citrus industry before a means of control was devised; the cottony rot or mold, attacking the fruit as well as the twigs; several types of gummosis due to fungi not known in Porto Rico; and a new bacterial disease of twigs, citrus blast. In Florida there is a disease known as nail-head rust or scaly bark, due to a certain fungus also as yet unknown to us. Jamaica reports a fungus gall on the branches, and in Ceylon a powdery mildew is so serious that it is said to be impossible to raise citrus fruits even for home consumption.

A considerable number of other diseases, all capable of causing heavy damage, could be mentioned, but these few will suffice to bring out vividly the importance of keeping at arm's length, by means of quarantine, any addition to the already formidable list of Porto Rican citrus diseases. Growers can cooperate most effectively in this important work by not attempting to import any citrus stock, and by reporting anyone who does. Specimens of any unknown disease, or type of injury appearing in the grove, should be sent to the Experiment Station for determination. Quick action in cases of this kind will make it possible to check a new disease in the incipient stage.

In studying the diseases of citrus in Porto Rico, it speedily becomes apparent that they are much the same as those reported for Florida, differing on the other hand very widely from those of California. That this should be the case seems reasonable, when it is remembered that the bulk of the groves of the Island originated directly or indirectly from budwood brought from the former State. There is, as might be expected, an even greater similarity to conditions existing in Cuba and the Isle of Pines, since the industry in those islands is but an offshoot of that of Florida, and in addition the soil and climate of Porto Rico and Cuba are much alike. Certain diseases, black melanose for example, which are of very minor importance or non-existent on the mainland, occur in the two regions.

In presenting the following information at this time, it is realized that to a considerable extent it is fragmentary, and that much intensive work remains to be done; but it has been prepared in the hope that such data as is available will be of sufficient value to

warrant its publication, and that it may serve as a basis for future work by pointing out the problems yet unsolved.

GENERAL CONSIDERATIONS.

Before taking up the specific diseases, there are certain general considerations which will be treated in some detail, since they are of the utmost importance to the growers. These, in brief, are the relation of cultural practices to health and disease in the grove, and general account of methods of control and prevention.

It is most difficult to draw a line between health and disease in plants. In a broad sense a tree may be said to be sick or diseased when it departs from the normal, but here again the difficulty is encountered of determining just what constitutes a normal tree. The normal of certain groves would in others be considered as decidedly abnormal. Without attempting to settle the question, consideration will be given to such abnormalities or injuries as are capable of causing, either directly or indirectly, financial loss by cutting down yield or rendering fruit unsalable.

Disease in a broad sense may be due to any one of a great variety of causes, principal of which, as far as the present subject is concerned, are those due to fungi, insects, cultural conditions, and physiological or unknown causes, the last so intimately connected with the preceding point as to be hardly separable. Insect injuries, while serious, are excluded from this paper, their study coming in the field of entomology. Bacterial diseases, though serious in other regions, are fortunately as yet unknown, or of negligible importance, in Porto Rico. A detailed exposition of the specific deseases due to fungi or to unknown causes will constitute the body of this paper.

This leaves for consideration at this point the important topic of the effect of cultural practices on disease. This will be of particular value at this time, when so many of the groves are suffering from an apparent decadence, although still comparatively young. It is the writer's belief that the cause for this condition lies in neglect or faulty application of the points about to be considered.

RELATION OF CULTURAL PRACTICES TO DISEASE.

Many growers fail to realize the effects, both direct and indirect, that cultural practices (cultivation in a broad sense) can have on the general health of their groves, and the resulting amount and character of the fruit produced. There are indeed several common diseases, of no little importance, which are directly accounted for by

neglect of these principles, and the disease is rare that is not influenced to some extent by them. It is too often the common attitude to expect the plant pathologist, or extension worker, to provide some cure which will eliminate in short order all the ills the grove is heir to: and there has been much disappointment when not only was such a cure not provided, but suggestions were made that what was needed was improvement in cultural practices.

SELECTION OF A GROVE SITE.

The first point to be given attention is the matter of selecting a grove site. The question of the character of the soil, or the soil type, is of minor importance, since citrus can be grown on a very wide range of soils, but the depth, possibilities of drainage, and related points must be carefully looked into. More than one grove in Porto Rico has been set in land where hardpan, or even rock ledges, were so close to the surface as to effect the growth of the trees within a few years. Hardpan is the reason for a number of decadent groves at the present writing. Even where the trees are not checked completely in their growth, they are so weakened as to fall easy prey to various diseases.

Of equal importance is the necessity of thorough drainage. Citrus trees are very susceptible to injury by standing water around their roots, and irreparable damage can be done by a sudden rise in the water table, or by flood water, in a few days' time. Where there is persistently poor drainage not only do weakened trees result, but the way is opened by the death of the roots to attack by specific diseases of the roots and crown.

In some districts drouths are of common occurrence, and it would be most advisable to arrange for irrigation where possible. This would provide for maximum, normal growth at all times. Here again, trees weakened by lack of moisture not only fail to make desired growth, through the loss of leaves, but the resulting weakening paves the way for withertip and similar troubles. A most direct result of drouth is of course the dropping of a large proportion of the fruit before maturity, or at such times as shipment is impossible.

Still another point, while on the topic of site selection, is that of slope. Blocks of trees set out on even moderate slopes thrive poorly, or even at times prove utter failures, where the soil is light and hence easily washed away, or where on heavier soils such precautions as are necessary to prevent this are not taken. Hillside groves are entirely feasible, if the grower cares to go to the trouble and expense

of installing a system of terraces, which will retain the soil around the roots; otherwise such sites are better avoided, or abandoned if already planted.

THE NURSERY AND PLANTING STOCK.

Too much attention cannot be given to selection of planting stock, since a productive grove is hardly possible without a solid foundation in the way of healthy trees from the nursery. Where time is available it will pay each grower to produce his own trees, thus assuring himself of healthy, vigorous trees of known variety and productive parentage. If this is not possible, a careful inspection before purchasing should be made of the nursery from which the trees are to come, to make certain that they are free of serious diseases or insect pests. In the event that diseases or insects are present, thorough spraying, pruning, or other corrective measures should be insisted upon before delivery. In addition the nurseryman should give a written guarantee as to variety.

In establishing nurseries, a site as far as possible from existing groves should be selected, in order that the rapidly growing seedlings may be kept free from infection by disease, or infestation by insects. The custom of planting nursery stock between the grove trees is particularly undersirable, not only because of the disease problems, but for other important considerations as well.

It need hardly be said that all possible care in cultivation and fertilizing will be amply repaid by the increased health of the trees, and their resistance to attack by fungi or to unfavorable growth conditions, when set in the grove.

A point deserving the greatest attention, although not directly related to the subject in hand, is the improvement of the industry by bud selection. Of late years considerable attention has been given to this phase of the work in California, and its value has been fully demonstrated by the studies of Dr. Shamel, of the United States Department of Agriculture. Briefly, this work consists in obtaining "tree-performance" records over a period of years (that is, the actual production as well as the character of the fruit of each tree) and then using for propagating material, buds from those trees that have given the highest yield of the desirable grade of fruit. This subject is discussed in detail in Farmer's Bulletin No. 794, which is distributed free by the United States Department of Agriculture, and will well repay a careful perusal.

As the work with citrus diseases progresses attention will be given to the possibility of checking certain of them by using buds from

resistent trees. The grower could well afford to give this matter some attention by searching for trees of this nature.

PLANTING IN THE GROVE.

The actual setting of the young trees in the grove involves a number of factors, which have a more or less direct bearing on the future health of the trees, and their resistance to disease. Care is necessary to prevent a drying out of the roots through too long exposure to air, and all broken or injured roots should be cut away, leaving smooth, clean wounds. Treatment of these cuts will hardly be practicable or necessary because of their small size. Such points as careful preparation of the soil, straightening out of the roots, and planting at such time as to avoid severe drouths, are so obvoius as to need no further elucidation.

The practice of setting the trees high, practically on the surface of the ground, so that when the roots are covered a mound of earth results, has much to recommend it, particularly where drainage is at all difficult or uncertain. In the older groves large numbers of trees, set with the crowns level with the surface, have settled so that they are now in basins, which if the soil is at all heavy, hold water for considerable lengths of time. Low setting increases the danger of injury from faulty drainage, and also adds to the possibility of the heaping of soil around the crown and base of the trunk, a condition that favors foot-rot and other bark diseases.

It might be thought that distance of planting would be without effect on the susceptibility to disease. It is, however, true that where trees are so close together as to interlock and so shade the ground completely, the resulting dampness and shade prove very favorable to bark diseases, foot-rot and pink disease in particular.

CULTIVATION.

Little need be said on the subject of cultivation. It will be readily apparent that there is an important relation, though indirect, between the cultivation given in a grove and the amount of disease. In general, the better the cultivation the healthier the trees, and hence their greater resistance to attack by unfavorable influences or parasites. Methods will vary greatly, depending upon age and location of the grove, character of the soil, and other circumstances, so that the actual cultivation practices to give best results are something that each grower should work out for himself by observation and experiment.

WIND PROTECTION.

Wind protection is likewise necessary, since a constant sweep of the wind such as occurs in Porto Rico prevents proper growth, and by favoring the increase of the scale insects paves the way for the anthracnose fungus, and other fungi of a similar nature which attack dying or unhealthy tissues. There is also a direct loss, where proper wind protection is lacking, through scarring, thorn puncturing, and dropping of the fruit.

Although wind protection is essential, it can nevertheless be overdone, or be carried out in such manner as to be harmful. It is a common observation that the use of bamboo means the complete loss of at least two rows of trees, and that from three to four more are influenced to the extent that they grow slowly, are misshapen, produce small crops of fruit, and have a decided tendency to withertip, or a dying back of the crown. This is produced by both the effect of the excessive shading and the strong root development of the bamboo. Ditches sufficiently deep to cut off the roots of the latter are required, and lines should be put in only at such distances as are necessary. In many places, at least every other line can be cut out without harm resulting, and with a saving of at least three rows of trees.

To some extent at least windbreaks, by producing quiet, humid conditions, aid in the spread and development of certain diseases, notably scab. This does not by any means make it desirable to abandon all breaks, but only to eliminate such as are unnecessary.

The ideal windbreak would be one of the leguminous trees, such as the guava (*Inga vera*), which are used for coffee shade. As temporary breaks the gandul (*Cajanus indicus*), the gallito (*Agati grandiflora*), and other shrubby plants are used. The second one named has given most excellent results, and it is especially recommended, being particularly free of diseases. The gandul, so generally used, is subject to a number of diseases, and is suspected of harboring several citrus maladies. Care should be taken to remove the plants of this species at maturity, when used for windbreak.

FERTILIZATION AND LIMING.

Fertilization, like cultivation, has an indirect though important bearing on the subject of disease or unthriftiness in the grove. It is well known also that the kind and quantity of fertilizer used has a direct influence on the quality of fruit produced, excessive nitrogen for example, tending to produce large, thick-skinned, puffy fruit.

Lack of fertilizer becomes readily apparent in the yellowing of the leaves, followed by a dying back of terminal twigs, and it may even induce a tendency to premature dropping of fruit. Certain recognized diseases, or types of diseases, are attributed to excessive amounts of nitrogen supplied in organic form. This point is considered more specifically later.

It is a surprising but true fact that soils of the majority of citrus groves of the Island are decidedly acid, in spite of the fact that they are in large part surrounded by or adjoin limestone hills, and in many cases are cut up by them into irregular-sized blocks. The use of lime to improve the physical condition of the soil, and to supply the other benefits derived from its use, has always been strongly recommended. It has been said, by those who have studied the matter, that, as a general rule, the lime required per acre to neutralize the soil acidity would amount to a considerable number of tons.

Lime may be applied in various forms, such as live lime, air slacked, or ground limestone, the second form being the one most commonly used in Porto Rico. No reports have been received of injury to Island groves from applications of lime in any form. Its use will be of value in promoting a better tree growth, with the accompanying result of more satisfactory yields of disease-free fruit.

A precaution is, however, necessary at this point in view of certain results reported from Florida. It has become apparent there that finely ground limestone, a form but little used as yet in Porto Rico, is capable under certain conditions of producing marked injury to the trees. This injury takes the form of a yellowing of the leaves, partial defoliation, multiple buds, bushy terminal growth, and a dying back. Studies by Prof. Floyd of the Florida Experiment Station have made it seem probable that this trouble is most apt to occur on light soils, and particularly on those lacking in humus. While it is considered doubtful that this trouble will appear here under present conditions, ground limestone should be used in moderation, and in conjunction with any such applications means should be taken to supply humus by growing a cover crop of velvet beans, sword beans, or similar legume, or even by light application of manure. Mulching the trees would also be of benefit.

PRUNING.

It would be foreign to the subject to enter into any discussion of pruning, other than to direct attention to the necessity of removing all dead and dying, or fungus-infected, twigs and branches. This

matter will be referred to in greater detail under various of the specific accounts to follow.

The important topics of picking, packing, and shipping are very directly concerned in their relation to losses sustained in the industry, but as they are more particularly related from a practical standpoint to blue-mold decay, their consideration is deferred to that point.

In the foregoing paragraphs an attempt has been made to outline the relation, often indirect, but none the less important, that cultural practices have in the prevention or control of disease. The grower who gives proper attention to this matter has the battle against the disease enemy half won.

GROVE SANITATION.

In addition to the above considerations, and as a general measure, aimed more or less at all fungus maladies, certain sanitary precautions are of importance, so important in fact that results can not be expected from specific measures if the general principles of grove hygiene are neglected. Briefly these are the removal, by pruning or otherwise, of all fungus-infected material, or that which in the usual course of events would become infected, and the prevention of reinfection by spores or other fungus parts brought in on field crates, wagons, or by implements used in cultivation.

Not only should all prunings be removed or burned, but all dropped fruit should be promptly disposed of. This material has a recognized fertilizing value, and if properly handled, can be used to advantage. In California prunings are sometimes run through portable cutting machines, and cut into small pieces easily incorporated with the soil. If no virulent diseases are present, this method is unobjectionable and could be adopted here. Drops are often buried in the grove, but are so poorly covered that at the first cultivation or even before, they are again exposed, and generally at a time when the rot fungi are sporulating freely. A deep pit at the edge of the grove or near the packing-house is the preferable manner, all things considered, for disposing of worthless fruit.

Simple quarantine measures should be devised to keep out any diseases that have not yet made an entrance, but which are present in neighboring groves. Field crates, wagons, tools, or other items of equipment should not be allowed to enter from infected groves. This matter becomes of more importance at the present day when the sound principle of building community packing-houses is gain-

ing ground. For disinfection of fields crates and other equipment, the most efficient and commonly used substances are corrosive sublimate (mercuric bichloride), copper sulphate solution, and formaldehyde. Formulas and directions for use are given in the appendix.

GROVE DIAGRAMS.

Most growers fail to appreciate the benefit, and even the necessity of having a diagram or plan of each block of trees. The system enables one to keep an exact record of individual tree production, and of other important data, such as character of the fruit, in as great detail as desired. Drone trees can thus be located and eliminated, and bud-selection work is not only greatly facilitated, but absolutely dependent upon some such scheme. From the disease standpoint a plan enables the grower to watch more accurately his sick trees. In brief a grove plan eliminates guess work, and makes for general efficiency in all phases of grove activity. Several schemes have been evolved, varying according to the manner of marking the trees, and to the method of taking and arranging the data. Suggestions and tentative outlines for orchard plans are given in Farmer's Bulletin 794. The adoption of some plan of numbering trees and taking individual tree data is most emphatically recommended, as a scheme that will pay handsome dividends.

TIME SPENT ON SICK TREES.

As a general problem, which may be taken up at this point, there arises the question of how much effort to expend on a sick tree before removing it. Some growers, especially those with the smaller groves, have a tendency to give considerable attention to attempted cures of such trees, however hopeless their condition, wasting both time and money. It is difficult to determine whether a tree will repay time spent in cutting out diseased tissues, in excessive pruning, or other corrective measures, but as a general rule it seldom pays to spend more than the time and money necessary to remove them.

A young, healthy tree properly planted and cared for, will very soon more than make up in returns for the tree it replaced. This advice will apply in cases of serious foot-rot, root rot, wood rot, scaly bark, and similar diseases. In undertaking that most difficult task, the restoration of abandoned or neglected groves, an interplanting, with the gradual removal of the old wrecks, will be found more feasible than a long, costly, and generally hopeless struggle to bring back the original stand to a productive condition.

SPRAYING.

An important phase of grove practice, and one which with the spread and increase of certain diseases will become increasingly so, is spraying or some system of applying fungicides to the leaves, fruits, and other parts of the tree in order to prevent fungus growth. It is generally overlooked or not thoroughly understood that spraying, as far as fungus diseases are concerned, must be entirely preventive, and can not be curative. This explains in large measure the numerous failures experienced in spraying operations carried out heretofore, although other points also enter into the situation.

Bearing in mind that fungicides must be applied in time to prevent infection, it is clear that the time of spraying must depend upon the periods when infection takes place, or in other words, upon the life histories of the fungi involved. In the specific accounts to follow, an attempt is made to indicate in as great detail as possible the proper time of application of the fungicides recommended.

Another reason for failure in spraying operations is the use of improper materials as, for instance, oil emulsion, which is an insecticide only, when a fungicide is required. In some instances spraying material is used at too great a dilution. A still further source of difficulty lies in the unsatisfactory nature of available labor, resulting in improper application. To secure perfect protection the entire surface of all susceptible growth must be covered with the spray material. This is very difficult, but the more care exercised in the actual spraying operation, the more nearly this ideal is approached and the higher will be the percentage of clean growth. The average laborer tends to miss a considerable proportion of the fruit and leaves of each tree, and to over spray the balance, which results in loss of material and may lead to injury through burning.

The machinery used is often inadequate for the task in hand because of lack of power or other mechanical defects. Improper spray nozzles are often a cause of trouble, particularly in the high-powered machines, where the opening tends to become enlarged by wear, and as a result the liquid is not sufficiently broken up into mist for best results.

Scarcely a grove on the Island is adequately equipped with spraying machinery. A machine or machines that require two or three weeks to cover a grove (provided everything runs smoothly, which is seldom the case) are not sufficient, since efficient control of certain diseases, scab in particular, necessitates more frequent applications.

The make or type of machine is of little importance from our

viewpoint, the requirements being a machine that will give satisfactory, sustained service. To avoid delays, spare parts for engine, and hose and nozzle equipment, should be at hand. Special men should be trained to manipulate the spray leads, and to operate them correctly without waste of material, but in such way as to cover each tree thoroughly. Watch must be kept to maintain sufficient pressure. Material applied in large drops is valueless if not harmful, a fine mist, uniformly applied, being the desired aim. The requisites then for a successful spraying campaign are adequate equipment, and the proper material applied at the proper time, and in thorough manner.

SPECIFIC DISEASES.

DISEASES OF THE SEED-BED.

DAMPING OFF.

Considerable losses are sustained by fungus attack in the seed-bed, by what is commonly known as damping off, since delicate seedlings are peculiarly subject to infection. Several fungi are doubtless involved, acting either independently or together, but the symptoms are practically identical. Infection occurs most commonly near the ground level, and is first noticed as watersoaked areas on the stems, that soon become brown and sunken. Following infection the seedlings fall over and death ensues. Isolated plants are first attacked, but small patches are soon involved, which enlarge and unite if prompt measures are not taken to check the trouble.

Control lies in careful management of the seed beds. The important point in this connection is to provide for thorough drainage. Excessive shading should be avoided. An inch of dry sand applied over the bed at the first appearance of the disease often checks its spread. The greatest possible care must be exercised in artificial watering. Thorough applications at as long intervals as possible are preferable to frequent sprinklings, which wet only the surface of the soil, and so aid the fungus. Since infection takes place at or near the crown of the plant on the ground level, care should be taken to keep this region as dry as possible to inhibit fungus action.

In selecting new areas for seed-beds, land should be taken which has not been used previously for this purpose, or land on which at least, damping off has not occurred. If this is not obtainable, the soil should be sterilized, either by steam applied under pressure for

twenty minutes, or by a one per cent formalin solution applied at the rate of one gallon of solution per square foot of surface. In the latter event the area treated is covered with sacking or other covering for several days to permit the formalin fumes time to act, and the soil is then worked over thoroughly before planting.

CROWN ROT.

True damping off attacks the seedlings only in the very early stages, and before the stem tissues have hardened. Another type of disease similar in its action has been noted which, however, attacked after the seedlings were some months old and had attained a considerable length of woody stem. The bark at the surface of the ground and finally for several inches upward was soft rotted, and the infected plants girdled. This disease also occurred in spots which enlarged rapidly.

The cause was a fungus technically known as *Sclerotium Rolfsii*, which is also the cause of a leaf disease of sugar cane, and a serious wilting of eggplant, pepper, tomato, and other crops. Under very moist conditions the vegetative growth of the fungus itself can be seen at the base of infected plants as a delicate, white membrane, on which are produced the sclerotia, or fruiting bodies. These are hard, globular, and yellow to brown in color, much resembling mustard seeds.

This disease is somewhat more difficult to control than ordinary damping off, but much again can be accomplished by careful drainage and prevention of overcrowding of seedlings, conditions very favorable to the parasite. Seedlings of the age attacked by *Sclerotium* can usually be transplanted, so that the fungus can be headed off by moving all healthy plants to a new location, spacing them properly, and arranging for drainage.

BENCH ROOTING.

A mechanical defect of citrus seedlings of very frequent occurrence is that known as bench rooting or twisting of the root. A similar trouble has been studied in rubber seedlings in Ceylon, and doubtless is to be found in seedlings of other economic plants. The twisting of the root interrupts or interferes with the passage of the sap and so finally may cause a stunting of the tree. It is apparent that these abnormalities originate during the germination of the seed, and are

caused by the inability of the delicate growing point of the young plantlet to force its way through the tough seed-coats in normal fashion. Rocks or other external influences are not concerned.

FIG. 1.—Bench rooting of grapefruit seedlings.

Absolute prevention could be secured by removing the seed coats, but as this is not practical, resort must be had to either planting the seed fresh before they have had opportunity to dry out, or after soaking them from thirty-six to forty-eight hours. This should reduce bench rooting to a minimum.

ROOT DISEASES.

Root diseases to date have caused comparatively little damage, so little, in fact, that practically no attention has been given to a study of this phase of citrus disease, beyond field observations. Losses have never been more than scattering trees, or rarely small groups. For this reason no attempt will be made to distinguish various specific diseases, but the term will be used in a broad sense to cover the loss of trees through any cause operating below ground.

In one grove a number of trees died suddenly and investigation

revealed that a high-water table was the primary cause, it being in some places within two feet of the surface. Neighboring trees on slightly higher land were unaffected. The trees had grown normally for a number of years, until their roots began reaching down below the water level. From this time on they became unthrifty, as evidenced by a yellowing of leaves, and dying back of twigs and branches. After a longer or shorter such period, death came suddenly. The final wilting of the leaves and drying out of the bark often took place within a very few days, as a result of girdling at the crown by a fungus, which had worked up along one or more of the main roots. This fungus (*Ustilina vulgaris*) is very common on dead wood, and is not generally considered parasitic. In the present case it had undoubtedly acted as a wound parasite, gaining entrance through the ends of the roots killed by the water. The fruiting or reproductive bodies were produced around the crown shortly after the death of the tree, as black, carbonous, crust-like layers, pitted with the innumerable openings into the spore sacks. Affected roots and trunks showed a characteristic dry white rot.

No indications have been found at any time of the presence of the truly parasitic root fungi reported from other citrus regions, *Rosellinia* spp., *Sphaerostilbe*, *Fomes*, or *Armillaria mellea*. These fungi are serious for the most part only where there is an abundance of dead wood in the form of logs or stumps scattered through the groves, on which they gain a foothold, and from which they spread to adjoining citrus trees. The fact that most Porto Rican citrus groves have been set in what was formerly open pasture lands of long standing, will make extremely improbable any infection from fungi of this nature. One fungus (*Valsa* sp.) has been commonly noted on exposed roots, and crowns of dead and dying trees. It is also common on dead wood, and beyond much doubt has only been able to attack, as did the *Ustilina*, by working in through wounds, or roots killed by standing water. It produces a dry rot.

In all cases of death of trees in this manner, the first steps should be to look for poor drainage, which is primarily responsible as far as observations to date show. When this cannot be corrected in low-lying sections of blocks of trees, replanting is not advisable, since the same conditions will almost certainly recur. All dead and dying trees should be removed, and care taken to dig out at least all of the larger roots, which would otherwise serve to harbor injurious fungi. Except where drainage is impossible or other factors inter-

fere, replanting almost immediately is entirely feasible, following a thorough working over the soil.

In addition to this type of trouble, due for the most part to faulty drainage, there has been present in a number of grapefruit groves a condition for which it has been impossible to locate a cause. Affected trees become unthrifty, there is a gradually increasing amount of dying back, and after a number of years, death. Older trees only are affected, and in so far as noted only those growing on the lighter sandy soils in the Manatí and Garrochales districts. Individuals may be attacked, or small groups. In the latter case the disease progresses outward from the center, attacking approximately a new line of trees each year. There is some tendency on the twigs to multiple buds, but no gumming, and no fungi are constantly associated with the trouble. A number of measures, particularly variations in fertilizing and cultivation methods, have had no effect. Very severe prunings have only delayed the inevitable death. Where it has been possible to make examinations, the roots have been to a considerable extent dead.

Some observers have associated this malady with Florida blight, which it resembles in some respects, though differing in others. It is not improbable that it is at least a closely related phenomenon. Blight was at one time the most dreaded of all Florida citrus diseases, and caused heavy losses. The cause was never ascertained, and but one recommendation was made with regard to it, to remove and destroy all affected trees as soon as possible. The same advice will apply here.

FOOT-ROT OR MAL-DI-GOMMA.

This is one of the best known and most wide spread of all citrus diseases, having been first noted in the Azores as early as 1834, since which time it has gradually spread to practically all other citrus-growing regions. The damage caused by this one disease in the various parts of the world, where it has been prevalent, will total millions of dollars; the loss in a sixteen-year period (1862–1878) in Italy alone being estimated at two million dollars. Florida has suffered very heavy losses.

The disease has long been known in Porto Rico, it having been in fact the first malady to cause appreciable loss to the industry. Many of the earlier groves, particularly lemon plantings, suffered severely, even to the extent of the loss of a large percentage of the

trees. Of late years, however, the disease has been distinctly on the wane, possibly due to natural influences, but attributed in large part to improved cultivation, use of resistent stocks, and increased knowledge on the part of the growers.

Foot-rot, or mal-di-gomma as it is known to many, is readily recognized. In the majority of cases the first symptom noted will be the exudation of gum at one or more points at the crown or base of the tree. On examination the bark at these points and for varying distances around will be found dead and gum infiltrated, resulting in a deep brown color. The wood beneath infected bark also dies. The disease is accompanied by a very characteristic odor, so distinct at times as to be readily noted some distance from the infected tree. The diseased areas are generally irregular in shape, extending ultimately, if not checked, a distance of one or two feet up the trunk, and a similar distance out along the main roots.

FIG. 2.—Foot rot. Base of grapefruit tree, showing cankers and wood rot of an advanced case.

The disease progresses with great rapidity at certain seasons, commonly during the spring months, and remains more or less dormant at others. During this latter period the tree makes an attempt by the formation of callus to throw off the disease, but is seldom successful, unless aided by the grower. These alternate periods of growth and quiescence result in rough scaly cankers at the crown. A tree will survive one or several seasons following attack, all depending upon the rapidity with which the disease girdles the trunk. The presence of foot-rot is evidenced in the top by a yellowing of the leaves, a general unthriftiness, dying back of terminal twigs, and very often by an exceedingly heavy bloom, which sets very little fruit. Such fruit as is present is dropped in the final stage of the disease, together with the leaves. As would be expected where girdling is involved, the death of an affected tree occurs very suddenly.

Cause.

The exact cause of mal-di-goma has been in some doubt, several theories having been advanced by the numerous workers who have

studied this problem. The Italian botanists have favored the theory of fungus origin, assigning the blame to a white mold-like fungus (*Fusarium limonis*), commonly found in connection with foot-rot cases. This fungus, or one practically identical with it, has also been found in Porto Rico, but it has not been evident through inoculations that it has any causal relation with the disease in question, acting rather as a follower or saprophyte only.

Of recent years, the most widely accepted idea has been that of a non-parasitic, or physiological disease, due to certain environmental factors. Briefly these have been considered to be alternating periods of drought and excessive moisture, close planting, poor drainage and excessive use of organic fertilizers. Observations have quite clearly shown that the disease is more prevalent in lowlands, or where drainage is poor, and that there is undoubtedly a relation between it and close planting. In spite of this, however, it is the writer's opinion, based on observations, that foot-rot is due to a definite fungus (not *Fusarium*), although studies to date have failed to locate it. The progress of the disease from one locality to another, and from tree to tree as well as the result of recent work in Florida, would seem to confirm this theory. The fungus now held responsible in Florida, also occurs in Porto Rico as the cause of a disease of beans and tomatoes, but preliminary inoculation tests have given negative results here.

Control.

It is interesting to note, that the method of handling affected trees is exactly that which would be followed if a fungus were known for certainty to be the cause. In brief this is tree surgery. All diseased bark should be cut away, well back into healthy tissue, using sharp instruments to insure smooth cuts. Care must be exercised that narrow points or bands of diseased tissue running out into normal areas are cleaned out, since otherwise these will remain as infection centers from which the disease will continue to spread. This cutting-out process must be performed not only on the trunk, but out along the main roots as well, in fact wherever diseased tissue exists. It is failure to observe this precaution that has negatived so many attempts at control. The practice has very commonly been to work down to the surface of the soil and there stop. The soil must be dug away from the crown roots, so as to expose them to light and air, and make possible a thorough search for all infected bark. Fol-

lowing treatment the roots should be left exposed for a time at least, and preferably, treated portions should not be recovered at all.

In addition to cutting away infected bark, all discolored wood should likewise be removed with a gouge, or chisel, although this is not so vitally necessary as the first step. The instrument used in this work should be sterilized at frequent intervals by dipping in disinfecting solutions (see appendix). All diseased bark and wood should be removed from the groves and destroyed.

When the wound has been thoroughly cleaned, it should then be protected against reinfection. As a preliminary treatment Bordeaux paste (see appendix for formula) is ordinarily recommended, and is efficient, a thick coating being applied over the entire wound surface. After a week or ten days some permanent covering is necessary, and for this purpose gas tar is recommended, although there are other substances that serve the same purpose more or less efficiently. This phase of the subject is discussed more fully under wood rot. In the majority of cases there is no reason why the tar could not be applied without the preliminary treatment, delaying several days until the wound has dried out somewhat. Where entire roots have been cut away in the work of eliminating infected areas, a corresponding cut in the top will be desirable.

This line of work properly carried out (and it is utterly valueless unless it is properly performed) is an expensive operation, and should not be undertaken when the disease has made any great headway. A common rule of thumb is to take out all trees more than half girdled. The loss in yield in seriously deseased trees, combined with the expense of treatment, make it preferable to replant.

As with many other diseases, much can be done in the way of prevention, and it should be the ultimate aim to control by this means, rather than by the more laborious and expensive cutting-out method. In this connection one of the most successful factors is the use of resistent stocks. As noted, lemon and to a less extent sweet orange roots are most susceptible. Sour orange and grape fruit, on the other hand, are very resistent. A few cases of disease have been noted on grapefruit, but it is thought that it will prove satisfactory as a stock, although it has not been in general use in Porto Rico sufficiently long to judge its ultimate behavior. To avoid foot rot, then, sour orange or grapefruit stocks should be used, particularly when planting in low lands, or where the disease has been prevalent.

As a further step in the same direction, close planting should be avoided, or in old groves, which have closed in, some pruning or even the removal of part of the trees to admit light and permit better air circulation around the trunks will be desirable. When the disease is present, or its presence due to natural conditions is feared, care should also be taken to keep the dirt away from the crown of the tree. A rank growth of vegetation should not be permitted under the trees. A very important point will be to prevent injury to the trunk or roots from hoes, or other cultivation implements.

In Florida excessive applications of organic fertilizers are sometimes supposed to aid the disease, but it is not thought that this possibility need be feared under Porto Rican conditions.

GUM DISEASES, GUMMOSIS.

Several distinct diseases attack the trunk and limbs of citrus trees, with symptoms so similar that much confusion has resulted in attempts at classifying them. Fawcett [1] in a very clear presentation of the subject recognizes seven types of gum disease, of which at least three are known to be present in Porto Rico. The others, root rot due to *Armillaria mellea*, a mushroom; Florida scaly bark, or nail head rust; brown rot, or Pythiacystis gummosis; and Botrytis or gray fungus gummosis do not, to the best of the writer's knowledge, occur here. Of the other three mal-di-gomma has already been dealt with, and an account will follow of the remaining two, psorosis or California scaly bark, and Diplodia gumming.

PSOROSIS OR SCALY BARK.

This disease, which is of considerable importance in Florida and California, is fortunately one which causes little concern in Porto Rico. In its characteristic form it is primarily a disease of the orange, and has been found in a few groves only. In as much as orange growing, as far as the cultivated groves are concerned, is decreasing little fear need be entertained of this disease ever becoming serious. It must not be confused with the nailhead rust, or scaly bark disease of Florida, which while very similar in outward respects, is due to a specific fungus, and attacks the fruit in addition. For this reason

[1] Cal. Agric. Exp. Sta. Bul. 262. See Bibliography.

the terms psorosis or California scaly bark are to be preferred to simply scaly bark for the Porto Rican disease.

The trunk and large limbs are the principal areas attacked, although in very severe cases the smaller branches and even the twigs will be affected. The disease is marked by the scaling off in flakes of the outer bark, a characteristic which accounts for the name of the disease. These diseased areas commence as small spots, often a fraction of an inch in diameter only, on the trunks or larger limbs. They increase slowly in size, ultimately coalescing to involve areas often several feet in length, and more or less completely girdling the trunk or branch. Some gumming accompanies the scaling off of the bark, but is more marked as gum pockets in the affected bark tissues than as an exudation on the surface.

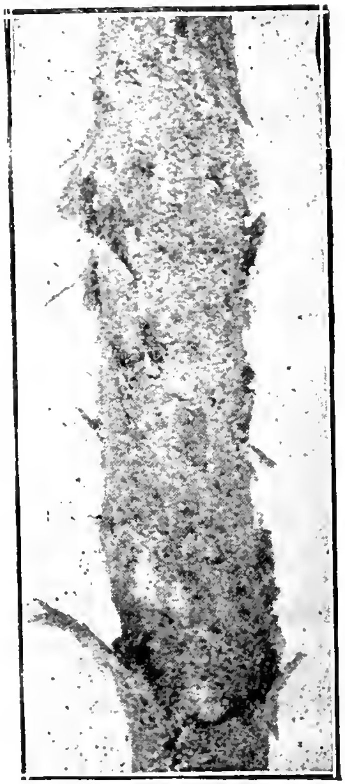

FIG. 3.—Psorosis, or scaly bark. On branch of orange.

New bark, irregular and much roughened, forms beneath the dead bark patches, so that very soon the ulcerated areas, due to a succession of healing and breaking out anew and so characteristic of the disease, appear. Ultimately, in the larger areas the bark dies through to the wood, and the resulting open wounds are soon infected by various wood-rotting fungi.

Affected trees after some time, often several years, begin to show signs of unthriftiness by a yellowing of leaves and the presence of dead wood. Limbs here and there are completely girdled and die, destroying the symmetry of the tree. Death of the entire tree, however, is generally long delayed, and it may linger on as long as ten years, bearing more or less fruit each season.

Cause.

No cause has ever been found. Certain fungi have been noted at times in connection with disease lesions—for example, the *Corticium* of pink disease—but there is no evidence that there was any causal relation. The malady is held by most workers to be due to

non-parasitic influences, in particular to irregular water supply, or other environmental factors. It has not been apparent, as far as local conditions are concerned, that the nature of the soil, cultural practices, or temperature changes have any relation to the disease.

Control.

There is but one possible course of action against scaly back. Where a tree is very seriously attacked its removal is advised. A young, healthy tree in its place will soon more than make up for the diminishing returns obtained from a scaly bark tree. As far as observations show there is no danger of re-infection in replanting. Where only small lesions occur, or where they are limited to one or a few limbs tree surgery can be called into action. Diseased branches can be removed, and areas on trunk and main limbs cut out, as described under foot-rot. All precautions in the way of sterile instruments, clean cuts, thoroughness in removal of affected tissues, and final treatment of the wound are most advisable. The usual reason for failure in this line of work is neglect to cut deep enough, or far enough out around each lesion. Scraping off the dead scaly bark is not sufficient; the affected bark must be removed to the wood.

Where this disease is present, regular inspections should be made several times a year, followed by prompt treatment of all lesions found. A system of tree numbering as recommended will aid in keeping track of affected trees.

GRAPEFRUIT GUMMOSIS.

A type of disease very similar to psorosis appears to a limited extent on the grapefruit, and is in fact by some workers considered identical. This supposition is borne out by the observation that where grapefruit and orange trees occur in the same block of trees and are diseased, the oranges exhibit typical psorosis symtoms, the grapefruit the somewhat different gummosis signs. Again this form of disease cannot be clearly differentiated from foot-rot, the two grading into each other, so that a line can be drawn only by calling one a disease of the roots and crown, and the other a disease of the trunk and limbs.

Generally speaking, this type of disease can be distinguished from psorosis by the more copious gumming, the fact that it is limited to

the trunk and large limbs, and because the bark is more quickly killed down to the wood, so that open wounds or cankers, through which wood rot infection can occur, are formed early in the progress of the disease. The scaling of the bark so typical of the first form is much less marked in this, often almost completely absent. Nor does the disease enter into any long chronic state as does the other, but is more apt to be thrown off by the tree, or to complete its course within a comparatively short time by girdling.

As with psorosis the cause is unknown, although observations point to a parasitic origin. Various fungi are commonly encountered in the gumming areas, but neither local studies nor the very extensive tests carried out in Florida have definitely connected any fungus with the disease.

Control.

If taken in time very effective control can be had by the methods outlined under psorosis. The same precautions are necessary.

DIPLODIA CANKER AND DIEBACK.

While little loss, except in one or two groves, has as yet been occasioned by this disease it may easily become most alarming. The writer regards it as the most threatening of all bark diseases. The trunk, branches, and even the twigs are subject to attack. Infection may take place at any point as manifested by gum exudate and browning of the inner bark. Infected bark finally becomes black and dries out. The wood beneath is also attacked, and in the case of the branches penetration in this manner may be complete. The infection may spread over very extensive areas, involving entire limbs and sufficient of the trunk to cause death. There is practically none of the scaling off of the outer bark noted in psorosis, but merely the death of the bark, with more or less gum flow from cracks and open lesions.

This form of disease is due to the work of a common fungus *Diplodia natalensis.* The fruiting bodies appear in great numbers on the surface of the dead bark, as small black carbonaceous, slightly roughened, hemispherical to flattened pycnidia, within which are borne the reproductive bodies or conidia. These latter are distributed by wind, water, and probably insects, as well as by various instruments employed in grove work.

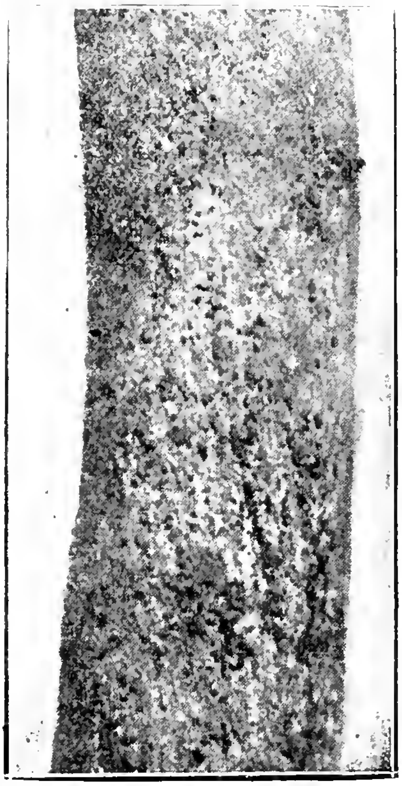

FIG. 4.—Diplodia canker. Showing black fruiting bodies of the fungus on dead grapefruit branch.

In attacking the twigs, *Diplodia* produces symptoms very similar to those of withertip, and in fact the injury caused has been called *Diplodia* withertip, or dieback. There is usually a slight production of gum to distinguish this malady from true withertip. In cases where this is not produced the disease may spread back into the larger limbs, or even the trunk, the gum apparently serving to check the growth of the fungus. The presence in advanced stages of the very characteristic fruiting bodies also helps to distinguish it from *Colletotrichum.* The latter, however, will also generally be present. In addition to the control measures outlined below, the general discussion under withertip will be applicable.

FIG. 5.— Diplodia dieback. Note the sharp transition between dead and living tissues.

Control.

Pruning of all diseased branches or twigs, and cutting out of lesions on the trunk, or main limbs will serve to control the malady if all precautions are taken. Exactly the same steps are necessary as have already been described for other bark diseases, but with

greater need for care, since a virulently parasitic fungus is present, and in great quantity. All prunings and other diseased material cut out should be destroyed, and all sanitary precautions observed.

Gumming will often occur where no specific disease is present, and is often due to mechanical injury, insect work, or other similar causes. Citrus trees form gum freely at any wound, apparently as a first step to healing, the gum being slightly antiseptic. In all such instances the wound should be thoroughly cleaned out and treated with a protective dressing, the cause being removed or corrected if present.

WOOD ROT.[1]

Some idea of the importance of this trouble may be gained when it is stated that there is not a grove on the Island which will not show some cases at least, and that there are groves in which practically every tree is infected. Instances have been seen where the disease had progressed so far that many trees were dead and the balance of a given block or grove in advanced stages of decay. Consequently there is no hesitancy in saying that this disease will play a most important part in grove decadence in the not very distant future. In fact, it is doing that at this very time, but the effects when considered at all have been referred to other causes, and it has been but seldom that any steps have been taken to prevent or control the trouble.

Characteristics and causes.

Wood rot is here used as a general term to cover a rot or decay of the wood of the trunk and larger branches, caused by a number of different fungi; for while several different types of rot may be distinguished, it is sufficient from the practical view point of control or prevention to consider them as one.

This disease has been well characterized as insidious. A tree may be in an advanced stage of decay without there being any surface evidences visible, unless careful search is made. The damage often becomes apparent only after a storm or other agency has broken a limb or split the trunk, exposing the rotted interior.

Several quite distinct types of decay occur, in some instances of the sap wood or outer wood layer only. In this case the bark will as a general rule also be involved, resulting in large trunk or branch cankers. In this type the wood through the action of the attacking

[1] A partial reprint of Circular 10, Insular Experiment Station.

fungi becomes soft and crumbly, so that eventually cavities are produced, which increase slowly in size as the rot works into the tree. Decay of this sort should be, and in most cases is, readily apparent to the grower, so that steps may be taken to check its spread, or eliminate it entirely.

However, there is another type, one that is more prevalent and much more dangerous, because not so easily located. This is a rot of the heart or center of the trunk or branch. An entrance is gained through a wound and from this point the rot spreads slowly up and down the trunk, and eventually into the larger limbs. Once an entrance is effected, decay progresses slowly (often over a period of many years) though none the less certainly, until the tree is destroyed. Lateral progress is not as rapid as that along the main axis of the tree. Rot of this type is generally dark colored and not less firm than normal wood until an advanced stage, when it becomes soft and friable. Rotted wood is, however, always much weaker than normal or healthy wood, which permits breakage by heavy winds, and other destructive agencies.

In the former type (sap rot or rot of the outer wood layers and bark) there is, of course, direct harm to the tree in that the water- and food-conducting tissues are destroyed, and the normal life processes of the tree interfered with, to an extent depending upon the size of the diseased areas. This would vary from a slight weakening to death, where the tree was girdled. In the case of heart rot, while possibly no direct injury results since heart wood is composed of dead tissues and takes no part in the transport of food or raw material for the use of the tree, the way is paved, through its slow but persistent action, for a premature death of the tree by helping to bring about a general weakening, in which condition other harmful agencies can complete the work of destruction.

Wood rot of all kinds is produced not by the action of the weather or by exposure to moisture or the air (although these are important contributing factors), but by the work of certain fungi. Several at least are concerned, it being possible to distinguish the work of one from that of another. Certain ones rot the sap wood only, others the heart; some produce a light-colored rot, and others a dark colored type. However, since the treatment or prevention of all types is practically the same, there is no need of going into further details on this point.

Without exception the fungi under consideration gain entrance only when some other agency has made an opening—or that is to

say, a wound—and for this reason fungi of this kind are known as wound parasites. In the presence of moisture the spores germinate on the surface or preferably in the crevices of the wound, producing a threadlike structure which penetrates the wood, dividing and subdividing as it progresses, and ultimately forming a complete net (invisible to the eye) in the invaded areas. Penetration of the hard wood tissues is brought about by the action of certain digestive fluids secreted by these fungus threads, or hyphae as they are called.

After the growth of the fungus, and the accompanying breaking down of the wood, have progressed for a considerable length of time, often for many years, fruiting bodies are formed. These are always produced at some points where the decay has reached the surface, and take different forms with the various species involved. The more common of these are the familiar shelf or bracket fungi (*Polystictus* spp.). (See Fig. 6.)

FIG. 6.—*Polystictus pinsitus.* The fruiting bodies of one of the common wood-rotting fungi.

On the lower surface of each bracket or fruiting body will be found a layer of very small, cylindrical pores, in which are produced the spores. Each of these spores, and great numbers are produced in each pore, is capable of again starting wood rot when it reaches a suitable location. They are carried by wind, water, birds, and other agencies to fresh wounds. Another very common type (*Schizophyllum*) produces numerous gray, oyster-shell shaped fruiting bodies, hairy on the upper surface, and below in place of a layer of pores, producing a series of gills or lamellae on which the spores are borne. (See Fig. 7.)

FIG. 7.—*Schizophyllum commune.* Fruiting bodies of the split gill mushroom, a very common wood-rotting fungus.

The manner in which infection occurs has already been suggested, but because of the importance of this point in connection with prevention, some details will be given. Under normal conditions, the outer bark presents an effective barrier to the entrance of rot, but as soon as this protective area has been broken, a way is opened for

infection. There are many means by which wounds may be produced, including those caused by mechanical agencies such as hoes, or other instruments or machines used in cultivation, animals, and sunburn. Injuries from these sources are commonly taken care of, but those resulting from the attacks of parasitic fungi are but seldom given proper attention. Foot-rot gives excellent opportunities for the entrance of wood-rot, and similar results follow attack by the pink disease (*Corticium salmonicolor*), psorosis, Diplodia branch and trunk cankers, and other trunk diseases.

A third source of wounds occurs as a result of routine pruning operations. Faulty or careless work, the leaving of stubs which delay or prevent healing, combined with improper treatment, or none at all, make this class of wounds the most common point of entrance for decay.

As a general rule the rebudding or topworking of citrus trees in Porto Rico has not been successful, and there can be but little doubt but that wood rot, following sunburn of unprotected branches and trunks, and untreated or poorly treated pruning wounds, will explain in large measure the poor results obtained here from a system so successfully carried out in other citrus regions.

Treatment and prevention.

Under the head of treatment, little need be said. For while it is quite possible to apply the usual methods of the tree surgeon to infected trees, it is not advisable from a practical standpoint under Porto Rican conditions. The expense of cutting out diseased wood, filling cavities, putting in braces, and caring for other details would be prohibitive. Treatment is advised only in incipient cases, or where the entire diseased area can be readily reached. This will practically apply only to sap-wood or bark-rot. A word of caution is necessary with regard to attempts at treatment. The removal of part of the rotted wood only, the part that can be reached readily, for instance, and the sealing over of the wound will prove of no avail, but on the contrary will permit the decay to progress more rapidly than otherwise, since the wound can not dry out. Moisture is a requisite for decay.

It is recommended as a practical and economic measure that trees badly diseased or unthrifty because of wood rot, or any other cause for that matter, be dug up and replaced with healthy trees from the nursery.

It is to prevention that most attention must be given. Simply

stated, this consists of preventing wounds in so far as possible, and of the proper treatment of those that do occur, in order to prevent infection by wood-destroying fungi.

Mechanical wounds due to cultivation instruments, animals, or other agencies should be prepared for treatment by having all projecting stubs, loose bark and ragged edges of bark and wood cut off or smoothed down so that healing over by growth of new bark tissues can proceed as easily and as rapidly as possible. The wound itself may be treated according to recommendations given in latter paragraphs.

In those cases where foot-rot, pink disease, psorosis, or other primary diseases are the causal agents more care is necessary. Diseased branches should be removed by cutting well back to a healthy limb, or to the trunk itself. Cankers on branches and trunk due to specific diseases must be carefully worked over to remove every trace of diseased tissue. This involves removing not only the discolored bark, but the diseased wood beneath as well. As a precautionary measure cutting out should extend well into healthy bark and wood, a half inch at least. All diseased material removed should be buried deeply or preferably burned. A piece of sacking laid around the tree will serve to catch small fragments as they are cut away from the tree.

In ordinary pruning operations for the removal of dead wood and the shaping of the tree, certain precautions should be observed. In so far as possible branches which threaten at some time to interfere with others or to spoil the symmetry of the tree should be removed. Superfluous limbs should be removed at as early a stage as possible to avoid large wounds, and other difficulties attendant upon their removal. Most important of all is the necessity of close, clean cuts. The careless habit of leaving stubs of various lengths, even if only an inch or less in length, is responsible for a large percentage of wood rot. To avoid splitting, the precaution should be taken of removing large branches in two pieces, the first cut made a foot or so above the base of the branch to be removed, and then the second, final, careful cut, at the point of union with limb or trunk.

Where there is any tendency to bleed, further treatment of wounds should be postponed until the surface is dry. With citrus, however, this is rarely necessary. In the case of wounds resulting from foot-rot, Diplodia canker or other diseases, the next step after cleaning out all diseased tissues and making the edges smooth to permit of

rapid healing, is sterilization of the surface to kill any spores which may be present. For this purpose either corrosive sublimate or Bordeaux paste may be used.

These substances, it must be understood, are not permanent in their effect, and must be shortly followed by a permanent wound dressing. In the case of pruning wounds, or those produced by causes other than fungi, the first application of a disinfectant is not usually necessary.

There is not at present available an ideal wound dressing, but several which are in general use, or which are recommended for use, will be mentioned.

The substance most commonly used in Porto Rico for this purpose is Carbolineum Avenarius, a propietary compound. Because, however, of the difficulty of making sure of obtaining the genuine article (other types of carbolinium being, so far as known, injurious), and the unsatisfactory features of the substance itself, its use is not recommended. It is quite possible for injury to follow its use; in fact, such cases have been reported.

Common white lead or white-lead paints are also in common use. These are far from satisfactory, although of some value if the precautions given in a following paragraph are adhered to. There have also been used to some extent various propietary wound dressings. These are fairly satisfactory but their use should be preceded by the use of a disinfectant in all cases.

Of all the many substances at present available for this purpose in Porto Rico, gas tar stands first. This is a product of the destructive distillation of coal in making gas, and can be obtained locally at a relatively small cost, an important point in its favor. Gas tar is given second rank by tree surgeons and others who have studied the question of wound dressings. Certain asphaltum compounds are considered best, but are not available here. The tar has been under trial at the Experiment Station with most satisfactory results, which fact, combined with field observations in groves where it has been used and the general favorable reports given it by experts in the North, leads us to recommend it alone for this purpose. No cases of burning have been reported or observed. As a general rule the only treatment necessary is a good coating of gas tar carefully brushed on after the wound has been thoroughly cleaned and prepared. It will penetrate a short distance into the living bark, but no more tissue will be killed than dries out normally in untreated wounds.

Finally, there must be considered the renewal of the dressings,

for no dressing, no matter how carefully applied, will be permanent. In fact, the usual method of covering the wound with paint or carbolineum and then considering the matter finished, often results much worse than if no care were given at all. This is because of the checking or formation of cracks in all wounds of any size, no matter how well they may have been covered originally. Such cracks provide ideal lodging places for spores, and subsequent infection by rot. This will explain why it has been the experience of some growers that more wood rot apparently worked in through treated than through untreated wounds.

The method of procedure to be followed to overcome this difficulty is simple. At the time the pruners go through the grove all old wounds should be re-inspected, and any showing cracks or other evidence of unprotected wood should be given another coating of gas tar, or whatever other material is in use for the purpose. Large wounds will in this manner often require an annual coating for a number of years.

PINK DISEASE (*Corticium salmonicolor*).

One of the striking diseases of the bark is the so-called pink disease, due to a fungus technically known as *Corticium salmonicolor*. In other parts of the world, Java and Ceylon in particular, this is a most serious disease, attacking a large number of economic plants, and much attention has been directed to it. Among the many hosts reported have been *Citrus* spp. rubber (*Hevea* and *Castilloa*), tea, coffee, chinchona, cocao, nutmeg, pepper, coca, gandul or pigeon pea, mango, and cinnamon.

In Porto Rico this disease has been found so far on but two hosts, the grape fruit and sweet orange, and in isolated instances only. It is very probable that at least the gandul (*Cajanus indicus*) is also attacked, since it is so widely planted in citrus groves, but no certain cases have yet been found.

The first report was received during a very wet period of weather in the fall of 1915, and additional cases have been found from time to time since. There are no indications that the disease will ever become serious. The absence of large tracts of woodland, in which the disease could vegetate during dry periods, will probably explain in large measure the failure of this potentially serious disease to assume alarming proportions here.

In such instances as it has been found, it has been present on

trees in low or very sheltered places, indicating that it is dependent upon humid conditions. In no case has an entire tree been killed, attack having been limited to one or at most several branches only. The disease very often begins at the base of a limb, or at a point where several originate, probably due to the accumulation of moisture at these points, permitting the germinating spores to gain an entrance. Once established the spread of the fungus is quite rapid along the limb. If very moist conditions prevail, the limb may be speedily girdled, but more frequently one side only (that which is most shaded) is attacked.

The presence of the thin, bright pink, fruiting layer of the fungus is striking, so much so that this disease could not be confused with any other. The pink area with its narrow white margin often reaches an extent of several feet, advancing with the rot of the bark produced by the vegetative portion of the fungus, and even at times growing out over the sound bark in advance of the root. Not only is there a soft rot of the bark with a characteristic odor, but the wood beneath is attacked as well, resulting in its drying out, and becoming discolored. Various insects, particularly wood borers, soon appear in the wounds, as do also various saprophytic and wood-rotting fungi.

FIG. 8.—*Corticium salmonicolor.* Illustrating the fruiting layer of the fungus causing "pink disease." Note the normal twig on the uninjured side of the branch.

The fruiting layer, at first a bright salmon pink, fades with age to a dull gray or dirty white. It also cracks into small irregularly, rectangular pieces, giving the characteristic appearance which has resulted in its having been sometimes called the "writing fungus," the fragments being thought to resemble hieroglyphics (Petch). Reproduction is brought about by spores developed in immense numbers on the pink areas and spread by wind, insects, and rain. Although acting in some cases as a wound parasite, it is quite capable in the presence of some moisture of penetrating otherwise uninjured bark.

Control.

The absence of any extensive infections makes unnecessary such drastic measures as painting the trunk or limbs with Bordeaux mixture. Very effective control is possible by prompt removal of all diseased limbs, making sure to cut well back of any infected areas. All wounds should be immediately treated with gas tar or other wound dressing. If taken in time areas on the trunk or main limbs can be cut as described for gummosis, observing all precautions.

It is desirable that attention be given to the possibility of its occurrence on the gandul, or other plants in and about the grove. Any such plants which come under suspicion should be destroyed.

DIEBACK OR EXANTHEMA.

Dieback or exanthema, a common disease in Florida and to a less extent in other citrus-growing regions, is of very limited occurrence in Porto Rico. In fact in but one instance has it been found to be present to a serious extent. This was in a block of orange trees, several of which were already dead, and others dying or in advanced stages of the disease.

The symptoms of true dieback are very distinct and have been worked out in detail by Swingle and Webber. Briefly they are as follows: Growing shoots turn yellow and become stained reddish-brown, finally dying back. On new unhardened growth distinct swellings, due to an accumulation of gum, appear. In serious cases the bark on both old and new twigs, and even the smaller branches, bursts and reddish-brown stained, corky ridges form. Young shoots very often droop in a striking manner, described as S-shaped. One of the most marked signs is the production of multiple buds in the axils of the leaves on young twigs. This results in a bushy terminal growth, most of which finally dies back. Many of the larger limbs eventually succumbing, a crop of water sprouts is produced from the lower part of the tree, giving a most ragged appearance. The foliage is said to take on a deep green color, although individual leaves sometimes show stained areas. The fruit loses its deep green color, and there is a tendency to split. Brown irregular stains appear on the surface as well as gum exudations, and a large percentage falls. Finally there is present an infiltration of gum in the angles of the segments at the center of many of the fruit.

It is only rarely in Porto Rico that any number of these symptoms are found together. Multiple buds and dieback are common enough,

but the additional signs are usually absent. Exanthema is not to be considered of any importance at present.

The cause of the disease is problematical, but it is usually considered to be a mal-nutritional disease, due to an excess of nitrogen supplied in barnyard manure or other organic form. Poor drainage is also thought to be a factor. Instances have, however, been noted in Porto Rico where trees located near stables or heavily manured were in the best of health, and on the other hand trees which had received no organic applications whatsoever showed dieback symptoms.

The disease is generally controlled by stopping for a time all cultivation and using mineral fertilizers only. Many growers have claimed that the disease could be cured by the use of blue stone (copper sulphate) applied to the soil around affected trees, and this idea has been apparently verified by experiments carried out in Florida by the United States Department of Agriculture. It was found that from four to eight pounds of copper sulphate in two applications gave most excellent results in restoring to normal condition even very sick trees.

WITHERTIP, ANTHRACNOSE (*Colletotrichum gloeosporioides*).

The withertip or anthracnose fungus is one of the most common, if not the commonest fungus, in and about citrus groves. Very extensive studies have been made of the fungus and the several phases of disease caused by it. It is one of the forms universally distributed in all citrus-growing districts, and if the view of some workers is accepted, it is also the cause of important diseases of apple, guava, mango, avocado, and a wide range of other economic plants. At least all varieties of citrus are very subject to attack by it. Of late years there has been a tendency to consider it more in the nature of a saprophyte or weak wound parasite, than the virulent parasite it has so often been pictured. It is true that it is of universal occurrence on dead and dying twigs, and in leaf spots. In fact, citrus leaves and twigs, to all outward appearances normal, will almost invariably develope the fungus, when externally sterilized and placed in sterile damp chambers.

On the other hand cases have been observed where death of branches, or spots on leaves or fruit were quite clearly due to the initial action of this fungus. As a result of observations and studies to date, it is believed that under Porto Rican conditions the fungus

is ordinarily a saprophyte or weak wound parasite, except in certain instances as will be noted hereafter.

Leaf spots.

On the leaves the spots produced are medium to deep brown, finally gray, in color with definite margins, circular to irregular in shape, and up to an inch and often more in diameter, even at times involving the entire leaf. The spots commonly have a characteristic zoned appearance, due to the production of the numerous, minute, fruiting pustules in concentric lines. The appearance of the spots is practically the same on both surfaces of the leaf. Repro-

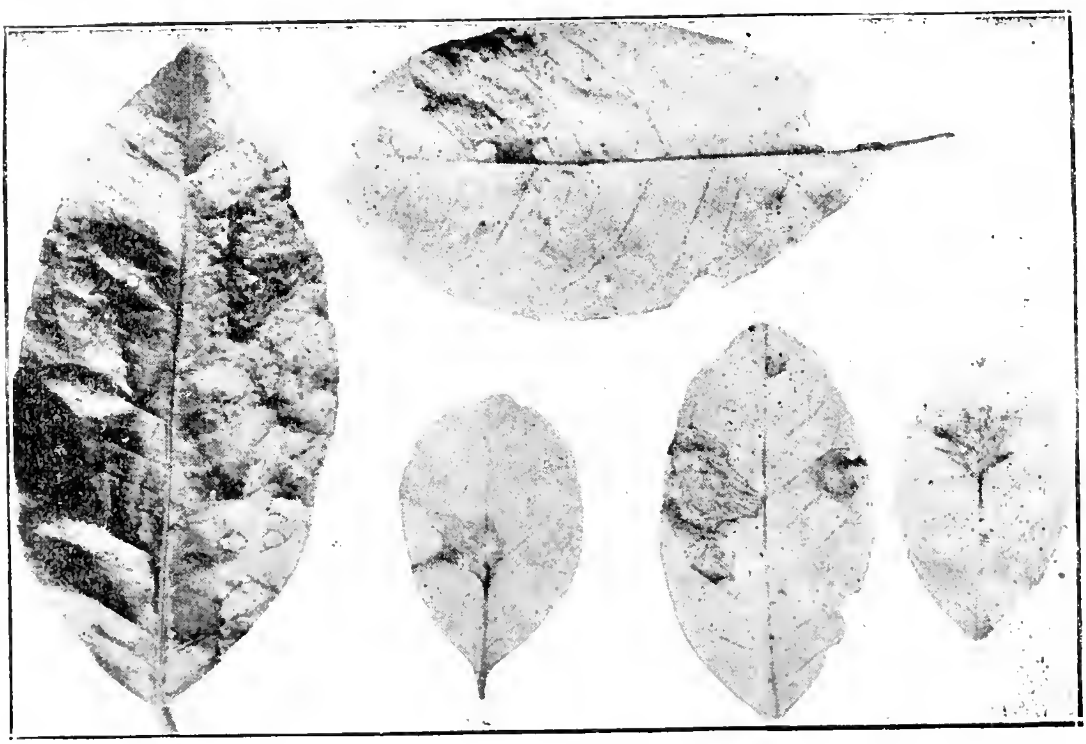

FIG. 9.—Anthracnose spots on leaves of lemon seedlings.

duction is brought about by means of the minute spores produced in great numbers in the sporodochia or fruiting pustules.

In a great majority of cases anthracnose leaf spots will be found in connection with scale infestations, they being particularly abundant on old leaves infested by purple scale. They are also commonly found on leaves partly consumed by biting insects, infection having occurred along the injured margins. Occasionally in contrast to this type of occurrence, cases will be found where no other initial injury is present. In one instance a large grapefruit tree was noted, apparently normal, except that a large percentage of the leaves was badly affected with anthracnose spots.

A much more virulent condition commonly exists among lemon seedlings in the nurseries. Here the spotting occurs in connection with scab, and not uncommonly reaches such proportions as to cause complete defoliation, with a resulting setback to the young trees. Except for their greater extent, and tendency to irregularity, the spots do not differ from those on other host species. The fungus involved is apparently *Colletotrichum glocosporiodes*, although careful cultural studies may reveal it as another species, as has been the case with the anthracnose of limes in Florida and California, or at least as a distinct variety.

A distinct type of leaf spotting, but probably due to the same fungus, has been observed in several newly set groves. After a season practically all traces of this form have disappeared. On the older and lower leaves, small deep-brown spots occurred, few to many, nearly circular, from two to seven or eight millimeters in diameter, and with slightly raised, very definite red-brown margins. It is thought that these spots were due to infection in the nurseries from the overabundant fungus material present there, but that the trees once they were removed to clean surroundings were able to resist, and finally eliminate the fungus.

Anthracnose of the fruit.

On the fruit typical anthracnose spots are produced. These are deep brown in color, generally sunken, and vary in size from minute points to areas several inches across. Any part of the fruit may be attacked. It is seldom that more than isolated cases will be found in a given tree, and most of these can be traced to some initial cause, a bruise, insect bite, or similar injury. Trees suffering from root rot, foot-rot, or other disease seriously impairing their health, show a large percentage of anthracnosed fruit. Fruit become more susceptible with maturity.

Surface infection, known as tear staining, is considered elsewhere, as is also the phase in which complete rotting occurs.

Withertip.

The most serious damage inflicted by this fungus results from attacks on twigs and branches, although here again it is difficult to say how much of the loss is really to be charged to this fungus, and how much to other agencies affecting the general health of the tree.

In the virulent form there is a sudden withering of terminal twigs, the leaves drop, and the wood dies back for varying distances.

In some cases branches of considerable size are involved, and more rarely even the major portion of a tree. The presence of the disease in this case will be very evident, the dead limbs standing out clearly from the normal portion of the tree. Affected trees show numerous dead twigs, a yellowing and shedding of leaves, and a general unthrifty appearance.

It is often difficult, in fact impossible, unless observed in the initial stages, to determine whether the death of the twig is due to actual attack by the withertip fungus, or whether some one of the many other causes which accomplish the same result has been operative, and the fungus merely a follower. A citrus tree tends to produce more wood than can be cared for, so that there is a constant natural pruning going on. Branches whose leaves fail to receive sufficient light to enable them to produce the necessary food supply, die, as well as those which because of their position fail to receive sufficient water. In mose instances the wither-tip fungus, as well as various other fungi, will be found fruiting on wood of this kind.

Much of the actual disease of this nature that occurs is due to attacks of other fungi, or to the combined attack of one of them and *Colletotrichum*. *Diplodia*, of which more detailed mention is made elsewhere, is common in such situations.

Control.

Preventive measure are primarily recommended, since the presence or absence of the disease is so directly dependent upon the state of health of the tree, which is in turn influenced by cultural methods under the control of the grower. The most important factors are cultivation and fertilization. When these are given proper attention, the tree will of itself be able to throw off the disease to a large extent. The use of an excess of nitrogen, either as nitrate of soda or in organic form, is to be avoided, since such a practice tends to produce succulent growth with little resistance. A balanced fertilizer (as nearly as the times warrant), which will give a normal healthy growth, is recommended.

Where the disease has actually gained a foothold and some corrective measure seems necessary, a thorough pruning out of all dead or weak wood is desirable, combined with such corrective steps as are possible. Pruning, if carefully done and reinforced with proper sanitary and cultural steps, will keep the disease in check. Spraying with Bordeaux has often been recommended, but this will seldom if ever be advisable under Porto Rican conditions.

MISTLETOE (*Dendropemon* spp.).

Parasites belonging to this group occur in a number of localities, particularly in the western part of the citrus district. The plants may be present as isolated specimens only, or at times may be so abundant as to cause considerable injury to the host tree. Mistletoe is a true flowering plant in contrast to the other parasites of citrus, which are fungi. It reproduces by means of seed enclosed in a sticky pulp, which causes them to adhere firmly to a branch or other object with which they come in contact. Birds are very efficient carriers, and are largely responsible for the spread of the parasite.

The seeds germinate and send root-like processes into the tissues of the host, erect shrubby plants developing. Possessed of green leaves, the mistletoe to a considerable extent manufactures its own food supply, but draws entirely, of course upon the host for raw materials, water and dissolved mineral salts. The limbs attacked die beyond the point of entrance of the parasite, the water supply being diverted to the latter. This results in an unsightly appearance, as well as a reduction in the bearing surface of the tree.

At least two species are found on citrus (orange and grapefruit) *Dendropemon bicolor* and *D. caribaeum*, both of which also occur on a considerable range of other hosts, some of economic importance.

As a control measure, the pruning out of infested limbs is feasible, together with similar action in neighboring non-citrus host trees, or even the removal of the latter if they are of no particular value, or heavily infested.

SCAB.[1]

Of the various diseases of grapefruit in Porto Rico, citrus scab, or lemon scab, has beyond much doubt assumed a position of first rank, and has been one of the chief agents in sending fruit to the cull pile and in the lowering of grades. During the past four or possibly five seasons—the time in which the disease has been especially virulent—it has been not at all uncommon in certain districts for the larger part of the crop of a number of groves to be so disfigured as to be worthless, representing a total loss on the season's work.

This has been especially true in those seasons when low prices have made it impracticable to ship anything but the highest quality of fruit. It would be extremely difficult to give any estimate of the losses that have been sustained, but they will reach a total of

[1] Abridged from Bulletin 17, Insular Experiment Station.

many thousands of dollars, including not only that caused by the immense quantity of fruit consigned to the cull pile, but that which comes from placing in the lower grades all that is disfigured by the disease.

Citrus scab is an introduced disease, which has been present many years, probably having been introduced originally from Florida. It first appeared on the sour orange and lemon, particularly on the seedlings of these varieties in nurseries, but as they were of no economic importance or were soon budded over to the immune orange or grapefruit, no attention was paid to the disease.

This was the status of affairs until the excessively wet season of 1911–12, when the grapefruit was attacked suddenly, and in the most severe fashion in the Bayamón section. Since that date there has been no decrease in virulence, and furthermore most of the other citrus districts have been invaded in turn.

Varieties attacked.

As has been noted above the sour orange (*Citrus aurantium*), and the rough lemon (*Citrus limonia* var.) have always been especially subject to attack, it being quite usual for one hundred per cent of seedlings in the nursery beds to be badly distorted and stunted. The other varieties of the lemon according to reports, were equally diseased at the time when they were grown in commercial groves here.

Shoots from the lemon roots of grapefruit trees are very subject to scab attack.

The lime (*Citrus aurantifolia*), the satsuma, and the mandarin (*Citrus nobilis* var.) have not been noted as susceptible in Porto Rico. The king orange (*Citrus nobilis* var.) is attacked, but not seriously. The kumquat (*Citrus japonica*) is free of the disease in so far as known.

The sweet orange (*Citrus sinensis*) is usually considered as immune, but in several instances trees have been found bearing a few scabby fruit, generally when in close proximity to diseased sour-orange trees. It is, however, considered not at all unlikely that it may lose this immunity at any time, as has but recently happened in the case of the grapefruit.

Of the grapefruit (*Citrus decumana*), three principal types are grown in Porto Rico on a commercial scale, the Duncan, the Marsh's seedless and the Triumph. The latter has at all times been immune, with the exception of slight infections found on seedlings. Because

of its poor shipping qualities and other commercial defects, further extensions of the planting of this variety are out of the question, even though its use would eliminate the scab.

The two other varieties are both very subject to the disease, no difference in their relative susceptibilities having been found, although, in the opinion of some growers, the Marsh is less severely attacked than the Duncan. Such differences as do occur from grove to grove can be readily accounted for, it is thought, by environmental or other local conditions.

It has been stated[1] that certain non-citrus plants, the gandul (*Cajanus indicus*) in particular, are subject to the same disease or one not distinguishable from it. No evidence was given to support this theory, nor has any developed since, and it is not believed that any fears need be entertained that the disease is present on plants other than citrus.

Appearance of the disease.

Citrus scab attacks the fruit, leaves, and young twigs. The

FIG. 10.—Citrus scab on young grapefruit.

first signs of infection are circular, minute, translucent areas, fol-

[1] Report Agricultural Experiment Station, Mayagüez, 1911.

lowed by a rapid production of the corky outgrowths so characteristic of the disease. On the fruit these corky outgrowths, wartlike in appearance, vary much in size and shape, often running together, or occurring in such numbers as to cover a large percentage of the surface of the infected fruit. At times plateau-shaped areas are produced, of an inch or more in diameter, irregular in shape, and marked by the dying of the epidermis and its breaking up into silvery scales. Again it may take the form of ridges, conical elevations, or other shapes.

The corky areas are dull brown in color in some instances, but very commonly are a dull red with brown margins. This latter stage occurs where the disease is especially virulent, the ridge and plateau condition being more often noted in instances where but little disease is present. This latter is the type found on oranges.

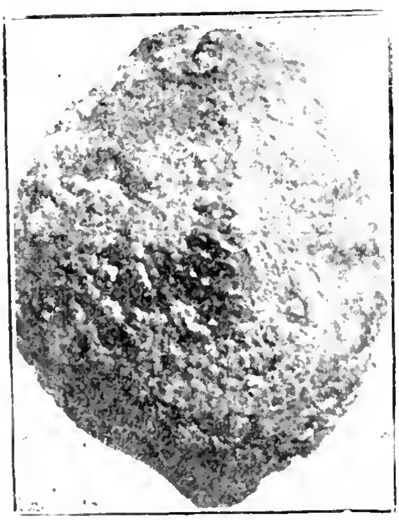

FIG. 11.—Citrus scab on full-grown lemon.

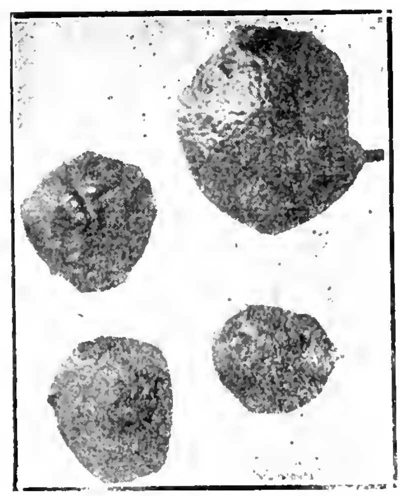

FIG. 12.—Young grapefruit deformed by citrus scab.

Young fruit are frequently much distorted, assuming triangular or other peculiar shapes. Those most distorted fall to the ground soon after attack. It may be noted that a larger percentage of scabbed fruit fall than of normal ones. Infected fruit remaining tend to regain their normal shape by subsequent growth, and as there is no increase in size of the initial infections, the great increase of the surface areas of the fruit gives all appearance of a partial recovery or "cleaning up" from the disease. This, of course, is not what takes place, but merely means that there has been no further spread of the scab areas.

Leaves are frequently distorted, the same corky areas appear-

ing on them as on the fruit. Where infection is not general, very marked conical projections, often as much as a centimeter in height, appear. (Fig. 14.)

Fig. 13.—Citrus scab on lemon leaves.

The diseased areas are surface infections only, there being practically no pene-

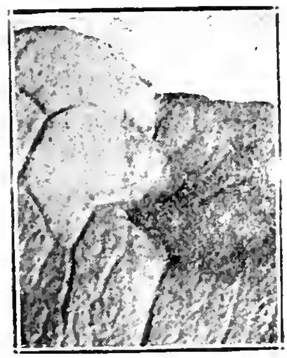

Fig. 14. — Characteristic conical projection caused by citrus scab on grapefruit leaf.

tration in either leaves or fruit of the inner host tissues. In fact so effectively are the inner tissues protected that scabbed fruits are no more subject to decay than normal ones.

Cause.

The disease is produced by the action of a parasitic organism. This spreads from place to place by means of exceedingly minute spores or spore-like bodies. Many workers have confused, in this connection, certain fungi with the casual organism, so that further work is necessary to properly place and name botanically the latter.

It is quite common to find one or more fungi in and about scab areas which are, however, merely secondary. The scab organism is not visible at any time to the unaided eye, either as a black mold or otherwise.

The reproductive bodies of the disease are carried in different ways by rain and dew, by wind, and quite probably by insects, and other agencies. Most of the mischief is accomplished by the first two, one affording a ready means of spread through any given tree, and the other accounting for the spread from tree to tree as well. The presence of the disease in each of the many infected groves can generally be accounted for by its having been present on the young trees, when they were brought in from the nursery for planting.

In the presence of sufficient moisture on the young unfolding leaves or newly formed fruit, the spore washed down from an infected leaf or fruit above, or blown in by the wind, begins its development by sending a delicate thread-like structure into the tissues of the host. As this growth continues, the plant reacts to produce the characteristic corky outgrowths, which represent its efforts to throw off the disease. It is successful in this to the extent that the disease never penetrates to any great depth, nor continues to develope any great length of time. The organism, however, remains alive in the corky lesions, and is capable whenever conditions are right (a period of wet weather) of producing a new crop of reproductive bodies. It appears to hold over to a greater extent in the leaves than in the fruit.

Contributing factors.

Scab attacks only the very young growth, so that the critical period during which infection is possible is quite short. In the case of the leaves, this period includes the time from the first breaking of the bud (when the leaves first show as green points) until the leaves are full size. Most of the infection occurs while they are from a quarter to a half an inch long and while the two halves are still folded together. Infections at this time cause distortion or the broad scabby patches over large portions of the surface, while later infections occur as isolated points only and the leaf remains normal in shape. New shoots coming out from old infected ones are peculiarly subject to attack.

The small fruit are susceptible from about the time of the fall of the petals, possibly before, until they are about an inch in diameter. Infection is especially apt to take place where several fruits touch, or where one is partly covered by a leaf.

The most important factor influencing the prevalence of scab is the nature of the weather prevailing at the time the flush and bloom appear. For the initial growth of the disease, moisture in the form

of rain or dew on the young tissues is necessary to permit of the germination of the spores and the entrance of the organism into the tissues. The ordinary heavy dews of the Island are quite often sufficient to permit of this, but a period of wet, cloudy weather produces an especially favorable situation for a severe attack.

Except as a carrier of the infection, wind has an indirect influence only, in so far as it serves to dry up the moisture in the trees and so prevent infection. In this connection it has often been noted that low-lying blocks of trees, or those protected by hills or heavy windbreaks, are, other conditions being equal, most susceptible. In most groves scab has first appeared in just such situations. The elimination of windbreaks to check scab is not recommended, except possibly in isolated cases where they have been put in too close or have become too large.

In any block of trees the amount of scab may vary from year to year, and to a less extent from tree to tree. Observations make it quite clear, that this is due in large part to weather conditions at the time of blooming and for a short time thereafter. Wet, cloudy weather will ordinarily mean a heavy visitation of scab, while clear, sunny weather means that the fruit comes through comparatively clean. There are, of course, many exceptions to this rule. In those groves which the disease has not yet reached all fruit remains clear in spite of the weather prevailing. In those blocks of trees which have been subject to disease, some infection will occur no matter how bright and clear the weather may be. It has been often noted that there are in most groves a number of trees, often only one or two, that are peculiarly susceptible, and doubtless serve as infection centers from which the disease may spread rapidly when conditions become favorable.

Very often the presence or absence of the disease in the trees of a grove depends upon the time at which the bloom and flush appear, it being quite common for great variations to occur in each block of trees in this latter regard. For example, those trees that bloom during the first two weeks of February might escape the bulk of infection owing to dry weather, while trees in the same block and similar in all respects, except as to later blooming, might some weeks later be very severely attacked.

No evidence has been secured to indicate that the stock on which the grapefruit is budded, (rough lemon, sour orange, and of late years, grapefruit,) has any effect on the relative amount of the disease present.

Unlike many other plant diseases, citrus scab shows a decided preference for healthy, vigorous trees, and it has been generally observed that, other conditions being equal, the best-kept grove or the most thriving trees fall easiest prey. It is rare indeed to find trees suffering from foot-rot, dieback, or advanced cases of wood rot also attacked by scab. In the many abandoned plantings examined no traces of it have been found, even though the trees are well protected, and infected groves are close by.

It is not, however, recommended that there be any lessening in the cultivation and fertilization of the grove in an attempt to control scab.

Control.

During the years when the grapefruit was free of the disease no steps were taken to check it beyond the budding over of the seedlings in the nursery as speedily as possible. No care was taken in setting out young trees to free them of what little scabby growth might be present. As this state of affairs occurred in practically every grove, it is not surprising that the disease has been able to spread so rapidly, once the resistance of the grapefruit was destroyed. Since then great efforts have been made to control the disease, particularly by the use of various sprays.

One very vital fact, that has been largely overlooked, is that all measures must be preventive and that a "cure," once the disease has a hold, is impossible. Once penetration of the host tissues has been effected, any amount of spraying is without avail, other than to kill such slight surface growth as there may be, which is readily replaced from within, after the spray material has washed off. To be effective the fungicide applied must reach and kill the spore before it begins its growth. Hence for absolute protection it would be necessary to keep the surface of the leaves and fruit completely covered during the susceptible period.

Removal of infected sour-orange and lemon growth.

This is a step generally recommended and one that should be followed out most carefully. It will be desirable to destroy, not only any wild sour-orange trees that may be present on the *finca*, but to search for any that may be growing in the vicinity in waste land, windbreak lines, or other holdings, especially small native plantings. In the case of lemon trees, removal is advised if they show any considerable amount of scab; but if, as has been observed in several

cases, single trees are free of disease, nothing will be accomplished by their destruction. The same recommendation will apply to other types of citrus grown as isolated specimens for home use of the fruit, or for the seed—destroy only when they become diseased.

The destruction of the lemon or sour-orange root sprouts, so common and so generally scab infected, is, of course, very desirable. Similarly in the nurseries there should be no delay in getting rid of infected material, and as a further step at this point, the young budded trees should be given such pruning as is necessary to keep the disease in check, aided when needed by spraying.

Pruning.

Heretofore it has been customary for writers on this subject to advocate the pruning of diseased leaves and twigs, and the removal of scabby fruit as important points in control. Recent observations made in groves, where such steps have been taken, have made it appear that no particular good is accomplished, and that, at best, results sufficient to pay for the expense involved are not received. It appears that no matter how thoroughly scabby material is removed, reinfection occurs in a propitious season, and apparently with undiminished intensity. Moreover, there must be considered the effect on the trees of removing such a large proportion of the bearing surface as is often involved in work of this kind.

On a small scale—that is to say, in small isolated groves or blocks of trees, or in instances where but a very few trees are involved—pruning, if properly performed, can be made effective. All scabby growth must be removed, and the trees examined sufficiently often to keep out all such material. When it is realized, that a single scabby fruit or cluster of leaves left after pruning, will suffice to reinfect the tree and probably others adjoining as well, the necessity of great care in this work will be seen. It will also be clear that the limit of practicability in this regard (number of trees that can be handled) is soon reached.

It has been observed that scab often makes a beginning in a grove by infecting over a period of several years one or a few trees only, scattered about through the planting. After gaining sufficient headway in these susceptible trees, it spreads over the balance of the grove, often in a single season. When such instances have been found, the budding over of the trees, using buds from nearby, thrifty, scab-free trees, has been recommended. Such a course, it is thought, will in the long run prove more effective than a series of prunings.

As a preliminary to spraying and as an aid thereto, as much as possible should be done in the course of routine operations to remove all sources of infection; that is, the scabby leaves and fruits. As far as the fruit is concerned, this merely means the picking and shipping of it before the new bloom comes on, and need take no particular extra time or money outlay. With regard to the leaves it should be the aim to take them out, in so far as practicable in the course of ordinary pruning operations. It is quite certain that this work as a special operation will not pay, even if time could be found for it. The point to be remembered in this connection is that the more of the infected material removed, the less there will be required of the spray applications.

Spraying.

That scab can be controlled in a practicable manner, though not eliminated, is certain. Very satisfactory results have been obtained in Florida, and some growers here have had measurable success.

Practically only two materials have been used or considered as fungicides for scab control. Bordeaux mixture and sulphur, the latter generally as lime-sulphur. Tests carried out in Florida, as well as such limited work as has been possible here, have demonstrated that Bordeaux mixture, properly applied, has an efficiency of from eighty-five to ninety-five per cent, while lime sulphur reaches a point of approximately thirty-five to forty per cent only. The former has, however, proven very objectionable because of the great increase in the amount of scale following its use, due in large measure to the destruction of various beneficial fungi which occur in enormous quantities in all Porto Rican citrus groves. If not taken care of in time the scale will, after several Bordeaux applications, become so plentiful as to cause very severe damage, or even the death of many trees. It has also been suspected of having an injurious effect on citrus trees from a physiological standpoint, and is more than apt to burn the tips of a new flush.

Lime-sulphur has an opposite effect in so far as it produces results at all. At the strengths commonly used it destroys only very small amounts of scale, but on the other hand does not apparently affect injuriously the beneficial fungi. It is, of course, very efficient in destroying rust mites and red spider, in decided contrast to Bordeaux.

Sulphur or sulphur compounds in the form of dust have been

tried out during the season just past, and found wanting in so far as scab control was concerned.

The situation arises then of two available materials, one effective but injurious, the other only partially effective but otherwise desirable. An attempt to arrive at a satisfactory solution of this difficulty is given as part of the suggested spray program.

The great difficulty in deciding upon the time of spraying and the number of applications, lies in the fact that it is impossible to know just when the principal bloom period will occur, or how many secondary blooms will follow. A heavy flush and bloom may be expected any time after the first of the year, but may not come until March in some districts. Following this there is scattering bloom and new growth until late April when, between that period and the middle of June, a second heavy bloom generally occurs. Throughout the balance of the year scattering bloom may occur at any time; very often in August or the late fall months. New leaves, of course, are coming on at practically all times. This seasonal variation makes it practically impossible to lay down any set program, but rather an attempt must be made to outline a tentative scheme to cover all possibilities, leaving to each grower the task of fitting it to his own individual circumstances.

Bearing in mind that all young growth is susceptible, it would theoretically be necessary to spray throughout the year, an impossible course. Practically, the best that can be hoped for is to give a limited number of applications at such times as they will accomplish a maximum amount of good.

Where the scab does not threaten to become serious, lime-sulphur or other similar sulphur compounds should be used, the first application being given shortly before the first bloom and flush of the season begins to expand. This is to be followed by another as soon as the bloom is at its height. The third application will come from a week to ten days later. Other applications may follow at the same or much greater intervals of time, all depending upon the rate of progress of the bloom, the coming of secondary flushes, and above all upon the weather. Periods of bright, sunny weather will make spraying unnecessary; wet, cloudy weather will necessitate frequent, careful applications: These points must be decided by each grower for himself.

Some growers have adopted the system of spraying once a week through the bloom period, making a total of eleven or twelve applications. This is unnecessary; three or four at the proper time being

equally effective. The weekly program is, however, much to be preferred to none at all.

As to the strength of solution to use, 1 to 30 is that usually recommended. This strength is very effective for rust mite, but does not kill a very large percentage of scale insects, nor is it as efficient a scab preventive as is desired.

It is therefore recommended that a strength of at least 1 to 25 (concentrate at 32° B.) be used for the second and third applications. Further tests may even make it desirable to use a greater concentration than this, but care must be taken to prevent excessive injury to young growth. It would be advisable for each grower to conduct experiments of his own as to the strengths that can be used without burning.

The important thing to be remembered is to make thorough applications at the critical time, using the material as strong as is considered safe.

The preceding lime-sulphur program may well serve for many groves, but it is unfortunately true that there are others so severely disease-ridden as to require a more strenuous program. For these the Florida schedule is recommended. The first spraying may be, as before, of lime-sulphur (1 to 25) before the bloom appears, a sort of clean-up spray to remove old scabby leaves and help protect the new growtn. Then the second application is Bordeaux mixture (3–3–50) at the height of the bloom, followed within a week or ten days by another at the same strength or by strong lime-sulphur, depending upon the weather and other conditions. The first application, however, other things considered, should be all the Bordeaux given, except in very exceptional cases, though this again must be left in large part to the grower's discretion. One or more additional lime-sulphur sprays may be given, if necessary, at the usual intervals.

MELANOSE (*Phomopsis citri*).

Melanose, a serious disease in Florida, has been reported several times from Porto Rico, but it appears that for the most part these reports have been erroneous, or that true melanose has been confused with greasy spot, a phenomenon of universal occurrence. True melanose has been found in a few groves only, and even in these cases has been confined to one or at most a few trees only. The most characteristic example found was on a sweet-orange seedling, which was severely infected, together with one adjoining grapefruit tree partially overhung by the orange. It has been observed by Faw-

cett[1] that melanose is more serious in the more northerly citrus districts of Florida, decreasing to the south, and practically lacking in Cuba. For this reason it will probably never assume any importance in Porto Rico.

Melanose is a disease of the fruit, leaves, and young twigs. It is characterized by numerous, very small (seldom over one-sixteenth of an inch in diameter), raised corky areas, yellow to deep brown in color, and often described as having the appearance of masses of burnt sugar. These corky projections are superficial only, never penetrating the inner tissues of the organ attacked. They may be scattered irregularly, or in the case of the fruit, be arranged in lines or partial circles. They have the additional characteristic on the fruit of being encircled by a break in the epiderm, giving a scaly appearance. Melanose-affected fruits have a russeted appearance and feel rough to the touch.

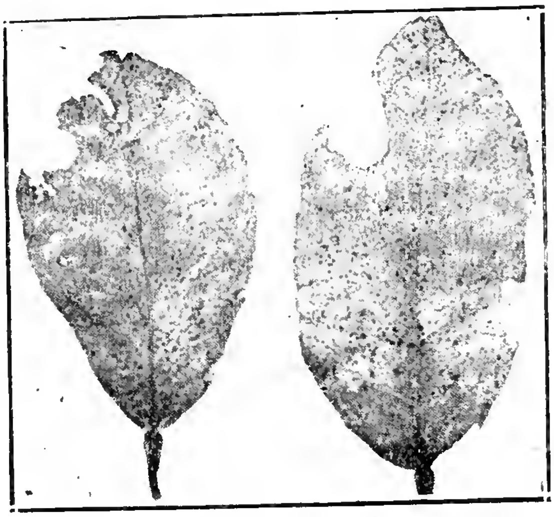

FIG. 15.—Melanose markings on orange leaves.

Leaves and twigs are subject to attack only while very young and before they have hardened. The fruit is susceptible until practically mature.

Melanose is due to surface infection by the spores of a fungus known as *Phomopsis citri*. It develops in dead twigs, producing very minute, black, immersed fruiting bodies, and the spores are carried by rain or other agencies to the new growth. The melanose markings themselves contain very little fungus growth and never produce spores.

In Florida the same fungus causes a rot in the mature fruit, almost exactly similar in outward appearances to the stem-end rot of Porto Rico, but this phase has not been noted here.

The disease can be satisfactorily controlled under local conditions by pruning out all dead wood. If at any time the disease should become more serious, a spraying schedule can be outlined for holding it in check.

[1] Bul. 262, Cal. Ex. Sta.

BLACK MELANOSE OR GREASY SPOT.

This almost universally present spotting of the leaves is known to many of the growers as melanose, and hence much confusion has resulted. Greasy spot is a common disease in Cuba and the Isle of Pines, but is less prevalent in Florida. Grapefruit leaves are especially subject to it, although it can be found on practically any citrus species.

It is characterized by generally numerous, somewhat irregular areas, occurring on both leaf surfaces, but more prominently on the upper, and varying from an eighth to a quarter of an inch in diameter. The markings are only slightly raised, and vary in color from a light yellow or mere translucence of the tissues through various shades of brown to a very deep brown or black. In the younger stages there is a greasy appearance, suggesting the name. They can easily be distinguished from melanose markings by the larger size and the fact that they are very slightly, if any, raised.

Trees of all ages and in all conditions of health and disease are apparently subject to this phenomenon, and although no fungi or other organisms have been found associated with it, indications point rather decidedly to parasitic origin. Inasmuch as no appreciable damage is caused, affected leaves falling very little if any sooner than normal ones, control measures are not considered necessary.

STELLATE MELANOSE.

Certain peculiar markings, given the name of stellate melanose, have been found on grapefruit leaves, but never to such an extent as to be causing damage. These markings, which occur on either side of the leaf, though more commonly above, may be few or many, and in their raised character and color are similar to melanose markings. They are, however, much more extensive, often from four to eight millimeters across, and irregular to stellate in shape. An especial characteristic is the longitudinal splitting of the branches of the individual spots.

The cause is not known. It is interesting to note in this connection that this spotting has been found in but three groves, and in each case following Bordeaux spraying. Orange trees and unsprayed grapefruit in the same groves were free of the markings.

ALGAL LEAF SPOT (*Cephaleuros virescens*).

The lime is especially subject to this leaf spot, to such an extent, in fact, that it almost serves as a distinguishing characteristic

of the species. The other citrus types are also subject to it, but to a less extent, heavy infections having been noted only in the vicinity of lime trees. In addition to citrus, a very large number of other evergreen-leafed trees and shrubs serve as hosts, among them being the breadfruit, camphor, hibiscus, guayaba, nispero, and many ornamentals. Very little damage can be attributed to this disease beyond the slight reduction in leaf surface.

The nearly circular spots occur, for the most part, on the upper surface of the leaves, vary in number from a few only to many, and in size range from a few millimeters to nearly a centimeter. They are slightly raised, at least after the initial stages, and in color vary from dull red to brown, and finally become deep dull brown. On dead leaves they take on a grayish tinge. The leaf tissue beneath each spot is killed, showing on the under surface as a brown area, otherwise unchanged, and more or less the size of the spot above. At certain stages of growth, the surface of the spot shows a deep orange or red fuzzy appearance, due to the presence of a large number of short, erect hairlike processes, which bear the reproductive bodies at their tips.

FIG. 16. — Algal leaf spot on lime leaf.

The parasitic organism involved is not a fungus, as with various of the other maladies with which we have been dealing, but an alga, a low type of plant related to the pond scums and sea weeds.

In addition to this form on the leaves, a type, very similar if not identical as far as the cause is concerned, occurs to a limited extent on the twigs and branches, particularly of sour orange and grapefruit, and is common on the gandul (*Cajanus indicus*). In this type the areas are irregular, several often coalescing and extending for considerable distances along the twig or branch. The fruiting stage has much the same appearance as in the leaf form. Some doubt is entertained as to the identity of the two forms, not only because of the slight differences in appearance, but because they have never been found in the same tree, or even in the same grove.

Corrective measures are hardly necessary, attacks on orange and grapefruit being so slight. It is probable that ordinary spraying

operations tend to keep it in check. The removal of affected, mature gandul plants will also doubtless aid in checking the twig type.

FRENCHING, MOTTLED LEAF.

The yellowing of leaves of orange and grapefruit trees is a very common phenomenon in Porto Rican groves, and may be due to any one of several causes. Various specific diseases, due to both fungi and unknown causes, are marked in part by a yellowing of the foliage, and this state of affairs is especially prevalent in abandoned blocks of trees, or those suffering from neglect. Trees which have borne a heavy crop of fruit will show considerable yellowing before the spring application of fertilizer is given, resuming normal color very quickly after this operation.

Yellowing of this nature is generally easily diagnosed and correctives can be applied, but there is a distinct type, commonly known as frenching or mottled leaf, the cause of which is obscure. In this case the leaves show irregular yellow spots, with definite margins, the background remaining green (Fig. 17.) Very often isolated trees only are subject to this spot, or a few limbs only in a given tree. Studies made in California seem to indicate that this trouble is due to a lack of humus in the soil, which is being supplied there by a system of mulching. The disease is hardly of sufficient importance to warrant any detailed attention here.

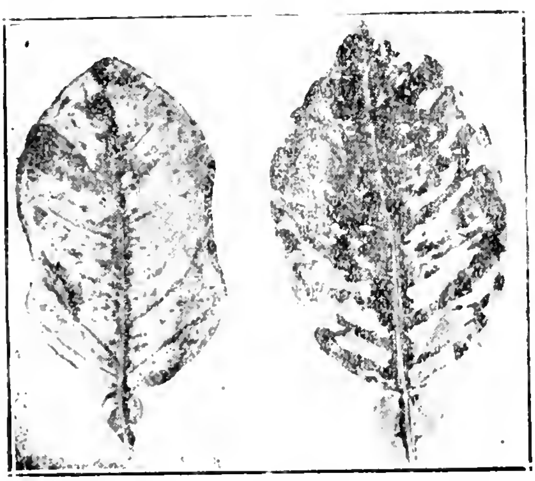

FIG. 17. — Frenching or mottled leaf of grapefruit.

Yellow spotting, a similar trouble of the leaves occurring in Florida, has not been noted here.

SOOTY MOLD.

The black, sooty layers of growth so commonly seen in the groves, and known to all as sooty mold, are fungus growths, but not of a parasitic nature. They live on the honey-dew or secretions of certain insects, in particular of the hemispherical and turtle-back scales and the wooly white fly.

No damage is caused, except through the cutting off of light from the food-manufacturing tissues of the tree by the black fungus layers growing superficially over fruit, leaves, and twigs. A variety of spore forms are produced, but whether they are of one species or several has not been definitely worked out.

Sooty mold can be eliminated by killing the scale or other insects, which it follows, by the use of oil emulsion or some other scalecide. Freedom from scale and hence from sooty mold, will eliminate in large part the necessity of washing the fruit, a procedure which increases the amount of rot.

FRUIT ROTS, OR SHIPPING ROTS.

The several fruit rots, or shipping rots as they are also known because of their developing during shipment, quite probably cause the greatest financial loss of any of the citrus diseases. They will even take first place over scab, since all rotted fruit is a dead loss, but much of that which is scabby can be sold in the lower grades. The amount of rot varies from season to season, depending upon moisture conditions, and other factors. The time of year, or in other words the maturity of the fruit, has an important bearing on the prevalence of rot, the percentage running high, as a rule, during the latter part of the shipping season, when much of the fruit is overmature. The actual loss will vary from one to fifty per cent of each shipment, possibly averaging five per cent for the season, wild oranges excepted, which have a much higher percentage. In estimating the loss, there must be taken into account not only the actual rot, but the lowering of price of the remaining sound fruit, the cost of repacking at New York, and the damage to the reputation of a brand showing heavy rot.

Several fungi are involved in the rotting, so that distinct types, stem-end rot, blue mold, anthracnose, and blossom-end rot are distinguished.

STEM-END ROT, DIPLODIA ROT.

This rot may attack the fruit at any time from partial maturity to delivery on the market. Certain groves or blocks of trees are much more subject to it than others, due in part at least to the greater abundance of the causal fungus on dead wood in the trees.

In a great majority of cases infection occurs at the stem end of the fruit, and hence the common name. A soft rot ensues, increasing very rapidly in extent until the entire fruit is involved. The rot works through the central pith portion of the fruit, appearing

at the blossom end by the time the softened area at the opposite end is an inch or two in diameter. Externally at this stage it appears as if infection had occurred at both poles of the fruit. The two areas rapidly coalesce. If attached to the tree at the time of infection, the fruit remains hanging but a short time only. Two or three days is ordinarily sufficient for the complete rotting of a fruit. Rotted areas at first show only a very slight change in color, but soon become light brown or tan, sometimes with black bands corresponding to the sections of the fruit. There may or may not be present an amber-colored juice exudate. After falling the fruit is rapidly consumed, shrinking, and ultimately becoming black and mummified. At this latter stage it will be covered with numerous minute, pimple-like projections, each of which represents a fruiting body of the causative fungus, *Diplodia natalensis*. The spores or conidia are produced in these pycnidia in enormous numbers. There is seldom any loss from this source of rot until the fruit is full grown, but from that period on, there is an increasing tendency to decay, particularly during periods of very wet weather.

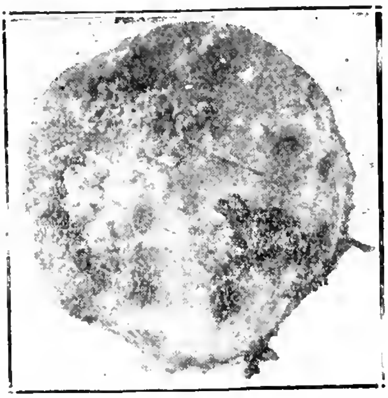

FIG. 18. — Portion of fruit rotted by *Diplodia* in damp chamber. Note the flocculent mycelial masses, each of which encloses a pycnidium or spore-producing sac.

In addition to this typical stem-end form, attack may take place at any point on the surface, particularly through insect punctures, bruises, or other injuries. Where one of a cluster of fruit is infected, the fungus, by working back into the fruiting twigs, attacks successively the others, killing back the branch as well for some distance. This is especially liable to occur where props are used, such a procedure apparently weakening the resistance of fruit and branch by cutting off the sap flow.

Rotting may occur at any time during the operations of picking, packing, and shipping, and under present conditions is very prevalent during the latter stage. Lack of refrigeration and the consequent high temperature and humidity make ideal conditions for excessive rot on shipboard.

Several types of soft rot are distinguished by those who handle the fruit in New York, principally based on the portion of the fruit first attacked and the presence or absence of the juice exudate, but all are due to the one fungus.

Control.

No one method will suffice to control or even to check this serious trouble, and it will only be by a judicious combination of the several points to be considered that any success will be obtained.

The first consideration should be given to a careful pruning out of all dead and dying wood, much of which under usual conditions harbors the fungus. A large proportion of the infection comes from this source. All precautions in disposal of prunings and treatment of wounds should be observed. In connection with this work all drops should be gathered up and buried, since, as already noted, they also serve as infection centers. Drops should be removed at frequent intervals.

The control of scale insects, particularly the purple and the chaff, has an important bearing on the problem, since scale-infested fruit are very liable to infection, particularly when the insects gather around the stem end. The puncture made into the fruit tissues affords the fungus a ready means of entrance. Scale insects are readily controlled by various spray compounds, Circular 9 of this Station treating of this phase of the problem.

Care in picking, packing, and shipping will aid in decreasing loss from this source. Since these points, however, more directly concern blue-mold decay, they are treated in detail under that heading.

BLUE MOLD.

Blue-mold decay was formerly more prevalent than at present, since control measures are better understood and are being practiced. This type of decay commences as a soft spot at any point on the surface of the fruit and spreads rapidly, two days being generally sufficient to bring about complete destruction. The affected area is soon covered by a thin white mold, which later turns blue-green or olive-green, the color being due to the layer of spores produced. If undisturbed an infected fruit becomes uniformly covered by the fruiting layer, giving off a dust-like cloud of spores if disturbed. Two fungi may produce this type of decay, *Penicillum italicum,* which is blue-green in the fruiting condition, and *Penicillum digitatum*, which is olive green. The first is marked by a narrow edge of white mycelium around the fruiting area, the whole fungus growth not covering the entire rotted surface; while with the latter species the opposite is true, a broad white mold layer advancing with the rot of the fruit.

Control.

The control of this decay is based upon the fact that uninjured fruit cannot be attacked by *Penicillium*, in contrast to *Diplodia* which is quite capable, some moisture being present, of attacking sound fruit. With the above fact in mind it will be clear that any and all of the points included under the phrase, careful handling, will be of importance in the operations of picking, packing, and shipping.

In picking, clippers with rounded points are necessary to prevent "clipper cuts," and fruit should be cut with as short stems as possible. To attain this result the stems are cut long at first, and then recut when the fruit is in the hand of the picker. Fruit should be placed carefully in the picking sack or basket, not thrown or dropped. There should be no sharp edges, broken slats, or protruding nails in the field crates. Considerable care is necessary in manipulating ladders to avoid bruising the fruit. The wagons or carts on which the fruit is hauled to the packing house should not be of the usual springless type, and in loading and unloading the boxes should be handled with all care. They should not be filled so full that part of their contents protrude, since such fruit will be injured by crates piled on top.

In the packing house the careful handling must be continued. All machinery should be arranged to cause a minimum of injury to the fruit, with elimination of all sharp corners, protruding nails, splinters, or other obstructions capable of breaking the rind of the fruit. A very good plan is to require pickers, packers, and others who handle the fruit to wear cotton gloves to avoid finger-nail scratches.

One of the most important matters to be guarded against is the accumulation of rotting fruit in and about the packing house. All rejected fruit should be removed daily and all field crates, wagons, and packing machinery should be kept clean, and those contaminated by rotting fruit dipped in some disinfecting solution.

There are many other details in this matter of careful handling in the packing and shipping operations, all of which have been treated in various other available publications to which the reader is referred, in particular to Farmer's Bulletin 696, "Handling and Shipping of Citrus Fruits."

ANTHRACNOSE.

The anthracnose fungus (*Colletotrichum gloeosporioides*), in

addition to the forms of disease already described, produces a soft rot of the fruit to a limited extent. Typical anthracnose spots first appear, and under favorable conditions the rot spreads so as to involve the entire fruit. In a majority of cases, however, anthracnosed fruit is rotted by *Diplodia* or blue mold, which gain entrance through the anthracnose lesions. Held under ordinary room conditions, a very large percentage of the anthracnose spots fail to continue their development, and an infected fruit ultimately dries up, unless attacked by one of the other fungi.

As already noted, the fungus involved in this type of decay is only weakly parasitic, and uninjured fruit from healthy trees will be practically free of it. To prevent loss from this source the measures outlined above for blue mold will be applicable.

Several fungi of decidedly minor importance have been noted on rotting fruit, for the most part merely secondary (*Aspergillus* spp., *Rhizopus* sp.), though occasionally as primary agents, but always entering through wounds. Control will be the same as for blue mold.

BLOSSOM END ROT.

Two types of blossom end rot have been distinguished in Porto Rico, which for convenience have been designated as the pink and the black. Both have similar external symptoms, the course of the infection and rotting is the same, and control measures are identical. Apparently only oranges are subject to attack, the navel orange to some extent, but other varieties more in particular. The disease is more prevalent, or at least causes most visible damage, at the beginning of the shipping season, infected fruit becoming less and less as the season advances and seldom being found after November. The disease is more prevalent in some years than in others, apparently dependent upon certain climatic influences.

The only marked external symptom is the bright orange color of infected fruit in marked contrast to the yellow or yellow-green of the normal fruit. Porto Rican oranges, at least those from cultivated groves, seldom become so highly colored. Following the high coloring, and sometimes to be seen before the fruit drops, there appears a brown, sometimes slightly sunken area at the blossom end, from four to ten millimeters in diameter.

On cutting into the fruit there is most commonly found a brown rot along the rag, which ultimately involves the sections as well. In the early stages there appears merely a discoloration in the skin

and underlying rag tissue, which later assumes a pink color, followed by the brown rotting. The apparent cause in this case is a fungus (*Fusarium* sp.). This form has been isolated a considerable number of times and by inoculation has been found capable of producing the rot. Investigations of this disease have shown that the anthracnose fungus is commonly present as a secondary agent, the rot progressing very slowly until this form enters.

Occasionally instead of the pink staining in the tissues at the blossom end there will be a black decayed area, which spreads even more slowly than the pink rot, and may remain confined to one section of the fruit only. The fungus in this case is known as *Alternaria citri*, and is common, though not serious, in California and Florida. The Fusarium type has been reported only from Porto Rico.

Infection in the case of both of these fungi occurs probably in the blossom, or while the fruit is very young. A certain percentage of infected fruit drops immediately, but in the others the fungus after a limited development becomes dormant until the fruit approaches maturity, and loses its power of resistance.

The complete life history of the causative fungi not having been worked out, control measures are somewhat uncertain, but will in the main consist of grove sanitation, the picking up of all drops, and removal of dead wood.

JUNE DROP.

A common phenomenon in commercial groves, and one which results in heavy losses at times, is the dropping of immature fruit. Following the bloom period there is always a heavy shedding of the newly formed fruit, and again in May or June there is very apt to be a second period, when dropping of fruit, by this time from an inch to two inches in diameter, occurs to a serious extent. A considerable portion of this dropping must be considered normal, the tree merely having set more fruit than it is capable of carrying through to maturity. If this natural thinning did not occur, steps to the same end would be necessary on the part of the grower.

However, much of the dropping must be considered abnormal, particularly that occurring during the second or June period. At this time many of the fallen fruit show irregular, brown, gumming areas on the surface and a brown stain at the blossom end. In the many cultures made of this class of material but one fungus has ever been found with any degree of regularity, *Colletotrichum*,

making it apparent that conditions other than fungus attacks are primarily responsible. Observations show that the chief factor involved is the moisture supply, the drier the weather prevailing at the critical time the greater the drop. Fruit lost under these conditions would naturally be attacked by the omnipresent anthracnose fungus, which is responsible for the browning and gumming

OIL BURNING OF FRUIT.

A very common form of injury to citrus fruits is one marked by a sinking of the tissue between the oil cells, causing them to project prominently. The sunken areas are normal in color at first, but finally become brown. The spots produced are irregular, may be one or several in number, and vary in size from the extent of a few oil cells to large portions of the surface. This type of injury, although noted on oranges, has been most serious on grapefruit.

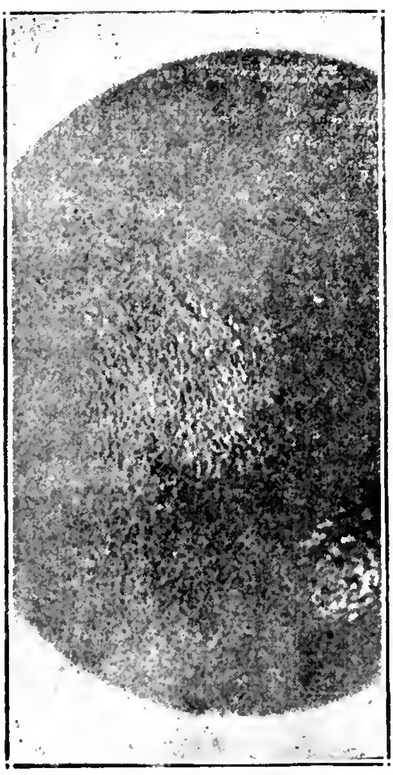

FIG. 19.—Oil-burning on grapefruit.

The amount of fruit affectd varies from grove to grove and from time to time, being correlated with the amount of moisture present, and the nature of the handling received. It is commonly observed that the spotting occurs most seriously during wet weather, and that green fruit is more subject to it than that fully mature. It has been demonstrated in California, and verified by experiments here, that this type of blemish is due to the injurious action of the oil of the fruit itself, when liberated by bruising or other surface injury, in the presence of moisture. Even very minute quantities are sufficient to cause the burning.

After the initial burning there are no further developments unless rot sets in. Ultimate disposition of fruit of this character depends upon the packing-house management. In some instances when shipping rot is very prevalent it is discarded, but it is generally merely placed in the lower grades, and has been found to carry very well. The edibility of the fruit is, of course, not harmed.

Control.

Certain suggestions can be made which should be effective in reducing to a minimum losses from this source. Until the fruit is fully mature, avoid as far as possible picking when the fruit is wet, and when this is not practicable, at least keep the rain and dew off the picked fruit. Pile the field crates in the packing house so that a maximum of ventilation will be possible. Since the actual burning follows injuries, every precaution must be taken to prevent scratching or bruising.

RUSSETING OR TEAR-STAINING.

Russeting is caused by several distinct agents, most important of which are the rust mite and the withertip fungus. Rust-mite injury is typically brown to black, occurring on the side of the fruit exposed to medium light, shaded and full-lighted areas remaining clear. The causal agent in this case is a minute mite, or spider-like animal, which is readily controlled by one to three sprayings with lime-sulphur or other sulphur compound, at the time the trouble makes its appearance.

Russeting due to fungus infection is brown in color, slightly rough to the touch, and more apt to cover the fruit uniformly, and independent of shading. Infection very often occurs in lines or bands running from the stem to the blossom end in very characteristic manner. This appearance has resulted in the name, "Tear-staining." The markings are entirely superficial, and are produced by slight infections by the withertip and possibly other fungi. In most cases the source of the infection will be found in dead twigs above the fruit which harbor the fungus. The carrying qualities of the fruit are not lowered and there is no further injury, the loss arising from the necessity of placing all such fruit in the lower grades.

The points outlined for control of the withertip fungus in its other phases will also apply here. The pruning out of dead wood is of special importance.

SILVER SCURF.

A rather common form of blemish on citrus fruits is that known as silver scurf or "thrips marks." These are irregular silvery areas.

due to the breaking up of the epiderm into small irregular flakes or scales. That the injury is superficial is readily shown by the ease with which the scales may be removed, exposing the normal tissue beneath. Small fruit sometimes become misshapen, but ordinarily there is no harm other than the lowering of grades. This injury is readily distinguished from scab in that raised corky areas or conical projections are lacking.

A number of possible agencies have been considered as the cause, and all are probably involved at one time or another. Slight injuries when the fruit is young, rubbing against thorns or branches, and the use of too strong spraying solutions cause some of the markings. A large percentage is thought to be due to the work of minute insects known as thrips. In Florida a fungus is commonly found in connection with the scurfing, but is probably secondary. The program of grove sanitation, pruning, and sulphur spraying recommended for other more serious troubles should keep silver scurfing down to a minimum.

SPLITS AND CREASING.

Splitting is a mechanical injury due to unequal pressure between the inner and outer tissues of the fruit. It is thought to be caused in part at least by a succession of periods of drouth and wet weather, the rind being unable to keep pace with the growth of the pulp, when the moisture supply is suddenly increased after a shortage. Additional cultivation or irrigation during a drouth would probably obviate this trouble if it ever assumed serious proportions. At present only the naval orange, an unsatisfactory variety, is at all subject to it.

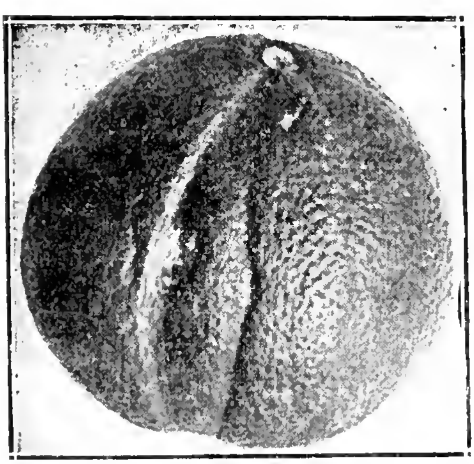

FIG. 20.—Creasing of orange.

Creasing (Fig. 20) is a similar type of injury in which there is a partial break only, the skin remaining whole, and the injury being apparent by a depression of the rind along the line of the break. The cause and control are the same as for splitting.

BUCKSKIN OR SHARK SKIN.

Buckskin is a disease of the epiderm or outer skin of the fruit only. The outer layer of cells is killed and takes on a characteristic gray, scaly appearance. The entire surface of the fruit is involved. An affected fruit ceases to grow and in addition to a very thick rind is generally lacking in juice so as to be of no economic value. Most affected fruit fail to reach any considerable size. Buckskin is readily distinguished from rust-mite injury, tear staining, melanose, and similar injuries to the surface by the fact that it covers the fruit uniformly, is light in color, and comparatively smooth to the touch.

It is more common on lower branches or in the center of the tree. The amount present varies greatly from year to year, being very abundant one season and entirely lacking the next. In some cases spraying with Bordeaux mixture has apparently increased the amount, and in others has been reported as preventing it. It is altogether probable that several causes operate to produce the same effect. Those suggested have been the combined action of mites and surface-growing fungi, and the alternation of periods of drouth and heavy rainfall.

SMOKY FUNGUS (*Leptothyrium* sp. ?)

This fungus is of comparatively common occurrence, particularly on the orange, but is, as a rule, overlooked by the grower. It forms irregular and often very extensive patches on the surface of the fruit. The fungus growth is confined, for the most part, to the regions between the oil cells, dimming the color of the fruit, and giving rise to the common name. Because of this scanty habit of growth, it has generally been considered as dust only. The brushes in the packing houses generally eliminate it sufficiently well, so that there is no loss through lowering of grades. Where lime-sulphur is used in the grove, this fungus will be sufficiently well controlled.

MINOR DISEASES AND DEFECTS.

Many minor diseases and blemishes occur on the fruit, leaves, and twigs, but all are either of so slight importance as to warrant no control measures, or are checked by operations designed to prevent more important troubles.

A leaf spot (Fig. 21) due to an as yet undetermined fungus occurs widespread, but on hardly more than a few leaves at a time. The spots are brown, slightly raised, plateau-like appear the same on both leaf surfaces, and vary in size up to one centimeter in diameter. Their shape is circular to irregular. Larger and older spots become gray at the center with definite, raised brown margins.

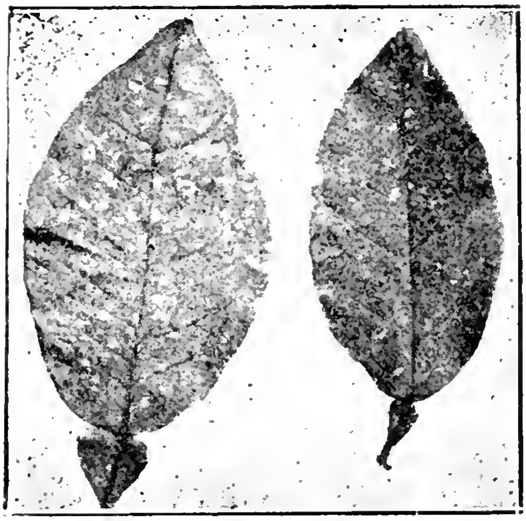

FIG. 21. — Spots on grapefruit leaves due to *Phyllosticta* sp.

A peculiar condition of terminal leaf clusters has been observed in grapefruit nursery trees, in which all the leaves are distorted, stunted, and one surface (generally the back) glazed. This is thought to be due to thrips injury.

Spraying injury may assume several forms. Bordeaux causes a burning of young unfolding tips, and on more fully developed leaves may produce a pitting (Fig. 22), the pits corresponding to the position of drops of spray material responsible for the burning. Lime-sulphur may cause injuries on fruit, with much the appearance of anthracnose spots, which fungus in fact generally follows.

FIG. 22.—Spotting due to Bordeaux mixture.

Knots in the rind occur in grapefruit, and possibly the orange. They are characterized by a slight raising of the skin, which feels hard. Internally they show as gum infiltrated areas. The cause is not known.

A common blemish on grapefruit consists of minute (a millimeter, more or less, in diameter), brown to black, slightly depressed markings on the surface. The epiderm only is affected, but since

the marks occur in great numbers the appearance of the fruit is marred. The cause is difficult to ascertain because of the absence of any fungus-fruiting bodies, and the minute character of the markings, which are probably due, however, to surface infections by some fungus, much after the nature of melanose. The withertip fungus is again suspected.

Leaves may show at times, irregular brown, very slightly raised areas which are caused by gum infiltrations. The initial cause is not certain, but in some instances is due to sun-burning.

Citrus trees commonly harbor a great variety of mosses, lichens, and other epiphytes (air plants). Several species of orchids and bromeliads grow on the trunks and limbs, as well as a number of ferns. None of these plants do any harm to the trees. On the leaves, several simple moss-like plants occur abundantly in shaded and damp parts of the grove, and may have some slight influence by cutting off light. Circular, silvery spots due to lichen growth (*Strigula* sp.) occur in similar situations.

Various minor fungi, occurring for the most part on dead wood, are recorded in the appendix. The several entomogenous fungi, which might at times, because of their abundance, come under the suspicion of the grower, are also enumerated and briefly described at the same point. It is desirable that the grower should be familiar with these beneficial forms, in order that such protection as is possible may be given them.

BIBLIOGRAPHY.

The brief list of references given here merely aims to mention such publications as it is thought will be of value to the Porto Rican citrus growers, and which are at the same time easily obtainable. There is, of course, a wide range of other publications on all the various phases of the subject, in large part technical, the substance of which, however, will be found in the ones listed.

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Citrus fruits. Coit. Published by McMillan, New York.

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Citrus scab in Porto Rico. Bul. 17, Insular Experiment Station.

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Scale insects and their control. Circular 9, Insular Experiment Station.

Wood rot of citrus trees. Circular 10, Insular Experiment Station.

Preparation of lime-sulphur. Circular 13, Insular Experiment Station.
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Handling and shipping citrus fruits in the Gulf States. Farmer's Bul. 696, U. S. Dept. of Agriculture.
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First report of the San Pedro citrus pathological laboratory. San Pedro, Isle of Pines, Cuba.
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Melanose and stem-end rot. Bul. 111, Florida Experiment Station.
Injury to citrus trees by ground limestone. Bul. 137, Florida Experiment Station.
Dieback, or exanthema of citrus trees. Bul. 140, Florida Experiment Station.
Citrus diseases of Florida and Cuba compared with those of California. Bul. 262, Cal. Agricultural Experiment Station.
A spotting of citrus fruits due to the action of oil liberated from the rind. Bul. 266, Cal. Agricultural Experiment Station.
The June drop of Washington navel oranges. Bul. 290, Cal. Agricultural Experiment Station.

APPENDIX I.

FORMULAS.

BORDEAUX MIXTURE.

Copper sulphate (bluestone)	3 pounds.
Live-lime	3 pounds.
Water	50 gallons.

The most convenient method of making Bordeaux, at least when large quantities are needed, is by preparing stock solutions. These are made by dissolving one or two pounds of copper sulphate in each gallon of water, to any amount desired, and similarly with the lime. These solutions may be kept for considerable lengths of time in their separate containers. Metal containers should not be used for holding them. The copper is best dissolved by placing it in a sack and hanging so it will be suspended just beneath the surface of the water over night. If needed in a hurry hot water must be used.

To prepare Bordeaux from the stock solutions, add three gallons of the copper solution to approximately forty-six gallons of water, and then stir in three gallons of lime stock, or a gallon and

a half of each stock if they are double strength. The concentrated solutions should not be mixed directly.

It is essential that all the copper be neutralized, since free copper will cause serious burning. This formula ordinarily provides a wide margin of safety, but a weak solution of ferrocyanide of potassium can be used for testing where there is any doubt. A black color, showing when a few drops are placed in a saucerful of the Bordeaux mixture to be tested, indicates free copper and more lime must be added.

BORDEAUX PASTE.

Commercial Bordeaux paste or powder can be used by adding sufficient water to make up a paste of the necessary consistency, or it can be prepared as follows:

One pound of copper sulphate is dissolved in one gallon of water. Two pounds of live lime are slaked in one-half gallon of water. The two mixed together give a satisfactory compound. This material deteriorates rapidly and should be made up only as needed. Stock solutions for Bordeaux mixture can be conveniently used by taking proper amounts of each.

LIME-SULPHUR.[1]

Unslaked lime	50 pounds.
Sulphur	100 pounds.
Water	50–60 gallons.

Any of the several form of sulphur, sulphur flours, flowers of sulphur, or powdered commercial sulphur, will be found to yield satisfactory results. The only requirement in this connection is pure sulphur (at least 99 per cent), no matter what its form.

This combination has been found to give most uniform results. It can, of course, be modified to any extent desirable as long as the ratio of 1–2–1 between lime, sulphur, and water is maintained. In the case of the water, enough should be used to allow for evaporation or else more added from time to time so that there will be approximately fifty gallons of product at the finish. Using more than fifty gallons of water will give a concentrate of less density, but one containing less sediment.

Equipment.—A great variety of kettles or boilers can be obtained for the preparation of lime-sulphur and in any size, adapted to the need of each grower. The large iron kettles used in the old open-

[1] Partial reprint of Circular 13, Insular Experiment Station, the English edtiion of which is exhausted.

pan method of sugar making have been used successfully in a number of instances. On a large scale an upright 5-horsepower boiler supplying steam to a number of 50-gallon barrels works very well. Plans for the erection of a lime-sulphur plant of any size are available, and can be supplied to anyone wishing them. Whatever the type of cooking outfit used the size of each batch should be sufficient to fill it not over two-thirds full, for otherwise there is danger of the solution boiling over the top.

Preparation.—Weigh out the required amounts of lime and sulphur (it is essential that the weighing be accurate in order to obtain the proper ratio), and place the former in the kettle or boiler with sufficient water to slack it. Start the fire beneath the boiler at the same time, and as soon as the slacking process is well under way, add the sulphur, either dry or as a paste. Better results, however, will be obtained if it is stirred up with water first to form a thin paste and all lumps broken up. A sifter or screen will help in this latter regard. When the two ingredients are thoroughly mixed and the slacking is completed, add enough water to bring up to the total amount required (50–60 gallons). If steam is used, no further additions are necessary, but otherwise water must be added from time to time, to make up for evaporation. If desired, the sulphur paste may be placed in the boiler first, followed by the water, and finally the lime. Results will be the same.

Stirring is quite essential, particularly during the first half of the boiling. Care should be taken to break up all lumps of sulphur. Working over open kettles will necessitate the use of goggles, the fumes and sulphur particles being injurious to the eyes. To maintain the proper volume a measuring stick adapted to the particular cooker in use will be found desirable.

The time required for boiling will vary somewhat, but is approximately an hour, or until the sulphur granules are all dissolved. To ascertain whether this point has been reached, take a sample and pour from one container to another, observing closely. If at the proper stage the solution will be of a dark-red color and free of sulphur granules. Too much or too little boiling will increase the amount of sediment, but of the two the latter exreme is preferable.

The soluion (concentrate) may be diluted and used immediately, or may be stored for future use. In either case it should be strained to remove the sediment, using a screen of from 30 to 40 meshes to the inch. The sludge which passes through is not objectionable.

The principal points to be guarded against during storage are evaporation, exposure to the air, and presence of acids, surplus lime, or other chemicals in the containers. Clean barrels may be used, and if it is not possible to close them air-tight a layer of heavy oil will protect the concentrate. This can be skimmed off before using the lime-sulphur. Changes in temperature will not affect the material.

Dilution.—This is the most important point in the entire process of using lime-sulphur, and is of equal importance whether the commercial brands or the home-made material be used. Two solutions may appear to be the same, but in fact may be found to vary greatly in density, so that unless dilution is properly carried out, burning may result. A concentrate will change in density from time to time due to evaporation, and it is therefore essential that a test be made each time portions of it are used. Safe and satisfactory dilutions are obtained by the use of a simple instrument known as the hydrometer (Fig. 23). These are made for a wide range of uses, and hence to obtain best results one especially adapted for lime-sulphur work should be used.[1] The best type is graded in two scales, the specific gravity or decimal scale, and the Baumé or degree scale. The concentration of lime-sulphur solution is generally given in terms of the Baumé scale but the other is necessary in making the calculations for final dilutions.

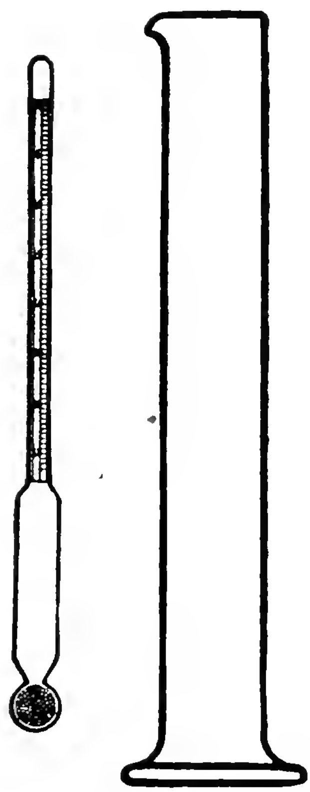

FIG. 23. — A lime-sulphur hydrometer showing the Baumé scale. On the right a cylinder of the type sold with the instrument. Any vessel of sufficient depth may be used in its place.

To obtain a spray of any certain concentration, obtain the density of the concentrate with the hydrometer, and then divide the decimal of this reading by the decimal of the density of the spray desired, and dilute according to the figure obtained. For example, if the concentrate has a density of 1.283 (32° Baumé) to obtain a spray solution of 1.026 (a 1–10 spray) the figure .283 is divided by .026, giving 10 plus, the number of dilutions.

[1] These may be purchased together with the cylinder for about one dollar from the Bausch and Lamb Optical Co., Rochester, N. Y.; Arthur Thomas, Philadelphia; Eimer and Amend Co., New York; and other dealers in scientific supplies.

It should be noted that this gives the total number of dilutions, and that the amount of water used would be nine parts to one of concentrate.

In using the hydrometer care must be taken to see that it is cleaned between readings. A little vinegar will help if it becomes coated with lime. The material to be tested should be free from sediment and at air temperature. Best results will be obtained by testing several days after the solution has been made. Read the hydrometer scale at the general surface of the liquid, and not at the point to which the liquid is drawn up by capillary attraction about the stem.

While it is preferable that the proper dilution be figured out from direct readings, using the rule given above, the following table has been prepared as being more convenient. It gives the approximate dilutions necessary to prepare the strengths most commonly employed. Thirty-two degrees Baumé has been taken as the standard strength

Lime-Sulphur Dilution Table.

If concentrate tests		To Make up One Hundred Gallons of Spray Mixture								
B.	Sp. Gr.	At 1-10 use Gals. Pts.	At 1-15 use Gals. Pts.	At 1-20 use Gals. Pts.	At 1-25 use Gals. Pts.	At 1-30 use Gals. Pts.	At 1-35 use Gals. Pts.	At 1-40 use Gals. Pts.	At 1-50 use Gals. Pts.	At 1-75 use Gals. Pts.
25°	1.208	13-4	9 0	6-6	5-3	4-4	4-0	3-3	2-6	1-7
26°	1.218	13-	8-5	6-3	5-1	4-2	3-6	3-2	2-5	1-6
27°	1.229	12-3	8-2	6-2	5-0	4-1	3-5	3-0	2-4	1-5
28°	1.239	11-7	7-7	5-7	4-6	3-7	3-4	3-0	2-3	1-4
29°	1.250	11-3	7-4	5-5	4-4	3-6	3-3	2-7	2-2	1-4
30°	1.261	10-7	7-1	5-3	4-2	3-5	3-2	2-6	2-1	1-3
31°	1.272	10-3	6-7	5-1	4-1	3-4	3-1	2-5	2-	1-3
32°	1.283	10-0	6-5	5-	4-0	3-3	3-	2-4	2-	1-3
33°	1.295	9-5	6-3	4-6	3-7	3-2	2-7	2-3	1-7	1-2
34°	1.306	9-2	6-4	4-5	2-6	3-1	2-6	2-2	1-7	1-2
35°	1.318	8-7	5-7	4-4	3-4	3-	2-5	2-2	1-6	1-1
Specific Gravity		1.026	1.016	1.014	1.011	1.009	1.007	1.004	1.002	1.001

NOTE.—One hundred gallons is the total dilution. To find the amount of water to be used subtract the amount of concentrate indicated from one hundred.

Sp. Gr. = Specific gravity.

Compatibilities.

It is very often desirable to combine other materials with the lime-sulphur, especially poison for biting insects. This permits of a saving of time and consequently of money. Lead arsenate (neutral) may be used in this manner without any fear of injuries resulting, although it does produce a chemical change in the lime-sulphur which shows as a darkening of the solution. As a matter of fact, the addition of the arsenate actually increases the fungicidal value of the sulphur.

Substances other than the lead arsenate should be used with extreme caution. Those of an acid nature—Paris green, for exampl—are dangerous, and even an acid lead arsenate should be avoided. Lime-sulphur and soap form an inefficient but non-injurious combination. Sulphur and oil emulsions are dangerous if used together, the emulsion being destroyed and free oil liberated.

DISINFECTANTS.

For disinfecting field crates, pruning instruments, and other equipment, the following may be used:

Copper sulphate.—Used as a solution made up at the rate of four pounds of copper to one hundred gallons of water.

Corrosive sublimate (mercuric bichloride).—Used in solution at the rate of one part of the poison to a thousand of water. The most satisfactory method of obtaining this substance is in the form of tablets to be purchased at most drug stores. A tablet in a pint of water gives a solution of the desired strength.

Formaldehyde.—Formaldehyde or formalin is purchased in liquid form, forty per cent strength. For disinfecting purposes one part of this stock is to be added to ninety of water.

APPENDIX II.

CITRUS FUNGI.

A considerable number of fungi have been collected on the leaves, fruits, twigs, and other parts of the different citrus species. A list is given here to afford some idea of the prevalence and distribution of the various forms determined.

Aspergillus flavus Link. Green mold on rotting fruit, generally secondary. Not common.

Aspergillus niger Van Tiegh. Black mold on rotting fruit, generally secondary. Not common.

Capnodium citri Berk. & Desm. Very common in all sections, forming black, superficial, sooty layers over fruit, leaves and twigs of all types of citrus fruits. Follows turtle-back, hemispheric scale, wooly white fly, and other insects. Not parasitic.

Cephaleuros virescens Kunze. Forming spots on living leaves, twigs and bark of lime,[1] lemon, sweet lemon, sweet and sour orange, and grapefruit. Very common in all sections.

Cladosporium citri (?) Massee. On living leaves, twigs, and fruit of grapefruit, lemon (all types), sour orange, sweet orange (rare), king orange. Common.

Cladosporium herbarum Link. On dead leaves, or in old anthracnose spots, Río Piedras, Pueblo Viejo. Saprophyte.

Colletotrichum gloeosporioides Penz. On living leaves, twigs, and fruit, and dead citrus material of all kinds. The cause of leaf spotting, withertip, fruit, spotting, fruit rot, and russeting. Exceedingly common everywhere, and on all host species.

Corticium confluens Fr. On dead wood of grapefruit, Campo Alegre.

Corticium salmonicolor B. & Br. Causing the death of branches of grapefruit and orange, Pueblo Viejo, Garrochales, Espinosa, Bayamón, Río Piedras.

Daldinia concentrica (Bolt.) E. & E. On dead citrus wood, Pueblo Viejo, Palo Seco, Garrochales, Espinosa.

Diplodia natalensis Evans. Causing fruit rot, twig blight, bark canker of orange and grapefruit, and collected in fruiting condition on mummified fruits twigs, bark, and roots, in all sections of the Island.

Hypoxylon fuscopurpurea Berk. On dead grapefruit branches, Campo Alegre.

Lecanidion cyaneum (Cooke) Sacc. On dead twigs, grapefruit, Campo Alegre.

Leptothyrium pomi (?) (M. & F.) Sacc. On fruit of orange and grapefruit. common.

Myrothecium verrucaria (A. & S.) Ditm. On dead grapefruit leaf, Río Piedras.

Nectria episphaeria (Tode) Fries. On dying bark, grapefruit, following *Corticium salmonicolor*, or other injury, Bayamón.

Penicillium crustaceum L. On dead grapefruit wood, Sabana Llana.

Penicillium digitatum (Fr.) Sacc. Olive-green mold, attacking all species of citrus fruits. Exceedingly common everywhere.

Penicillum italicum Wehmer. Blue-green mold on all types of fruit. Not common.

Peniophora cinerea Fr. On dead wood and twigs, orange and grapefruit, Pueblo Viejo, Campo Alegre, Espinosa, Bayamón.

Peniophora flavido-alba Cooke. On dead wood, grapefruit, Vega Baja.

Pestalozzia guepinia Desm. On grapefruit leaves, Espinosa.

Phomopsis citri Fawcett. On living leaves, twigs, and fruit; and dead twigs of orange and grapefruit, Río Piedras, Palo Seco, Bayamón.

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[1] The following scientific names for the citrus species are recognized:

Citrus decumana, grapefruit, pomelo.
Citrus sinensis, sweet orange.
Citrus limonia, lemon, sweet lemon, rough lemon.
Citrus aurantium, sour orange.
Citrus aurantifolia, lime.
Citrus nobilis, king orange, mandarine, satsuma, tangerine.

Polystictus occidentalis Klotzsch. On grapefruit, in connection with wood rot, Sabana Llana.

Polystictus pinsitus Fries. On grapefruit (dead wood), Espinosa.

Rhizopus nigricans Ehr. Causing a rot of fruit. Not common.

Schizophyllum commune L. Common as a wood-rotting fungus, and in one instance as a fruit rot.

Sclerotium Rolfsii Sacc. On dead grapefruit wood, and as the cause of crown rot of seedlings, Bayamón, Río Piedras.

Septobasidium lilacinum Burt. A superficial papery layer around grapefruit trunks, Bayamón, Espinosa, Palo Seco.

Stereum albo-badium Schw. On dead limbs, grapefruit, Espinosa, Vega Baja.

Stereum coffearum B. & C. On dead wood, sour orange, Río Piedras.

Stictis radiata Pers. On dead twigs, grapefruit, oranges, Sabana Llana, Espinosa, Campo Alegre.

Tryblidium rufulum Spreng. Very common on dead wood, particularly prunings left beneath the trees.

Ustilina vulgaris Tul. In connection with root rot of orange and grapefruit, Palo Seco.

ENTOMOGENOUS FUNGI.

Aschersonia cubensis B. & C. Growing on various scale insects, which are generally undeterminable, in the form of hemispherical masses, two to three millimeters in diameter, scattered, commonly on lower leaf surfaces, buff, finally red at the center. Common in all districts.

Aschersonia turbinata Berk. Very similar to the above, except that the fungus masses are top-shaped, attacking various scales. Common.

Cephalosporium lecanii Zimm. Forming a white powdery layer on hemispheric and turtle-back scales,[1] Sabana Llana.

Microcera Fujikuroi Miy. & Saw. On Florida red, and chaff scales, on orange and grapefruit. Infected insects assume a bright scarlet color, the fungus appearing as small erect, pink, flask-shaped bodies, Mayagüez, Bayamón, Pueblo Viejo. "The pink-headed scale fungus."

Myriangium duriaei Mont. & Berk. Forming small, sessile, black masses on white and purple scale on lime, lemon, orange, and grapefruit. "The black fungus." Common.

Scolecoconectria coccicola (E. & E.) Seaver. On white and purple scale, forming small white masses, and finally minute spherical, gray to buff perithecia. Common. "The white-headed fungus."

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[1] The various scales mentioned as hosts of the above fungi are technically known as follows:

Star scale, *Vinsonia stellifera* Westu.).
Hemispherical scale, *Saissetia hemispherica* (Targ.).
Turtle-back scale, *Saissetia oleae* (Bern.).
White or snow scale, *Chionaspis citri* Comst.
Chaff, or articulate scale, *Pseudaonidia articulatus* (?).
Florida Red Scale, *Chrysomphalus aonidum* (Linn.)
Purple scale, *Lepidosaphes beckii* (Newm.)

Septobasidium spongia (B. & C.) Pat. Forming a brown weft-like layer over white and purple scales, and often reaching an extent of several inches on fruit, leaves, and twigs. Found sparingly in all districts.

Sphaerostilbe coccophila (Desmaz) Tul. On purple, and chaff scales, producing small, red, flask-shaped fruiting bodies, and later clusters of minute, scarlet spherical perithecia. "The red-headed fungus." Common everywhere.

Tubercularia coccicola Stevenson. Forming sessile pink masses on white and purple scales, grapefruit, Espinosa, Río Piedras, Pueblo Viejo, Bayamón. Common. "Pink scale fungus."

In addition to these named species at least three others occur more or less commonly, attacking for the most part the white and purple scales. These are (1) a form producing a thin black layer with white margin, over large areas on trunk, and limbs; (2) a form producing small, globular, gray to black fruiting bodies borne on a short, erect stalk; and (3) a form consisting of small masses of loose brown mycelium (not forming continuous patches as does the *Septobasidium*).

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A Check List of Porto Rican Fungi and a Host Index............JOHN A. STEVENSON.

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A CHECK LIST OF PORTO RICAN FUNGI AND A HOST INDEX.[1]

By John A. Stevenson, Pathologist, Insular Experiment Station.

INTRODUCTION.

Published information concerning the fungi of Porto Rico is scattered through a considerable number of articles, which have been issued to a large extent outside the Island, so as not to be readily available to those attempting the study of this group of plants locally. For this reason it has been considered desirable to compile and present in one publication a list of all fungi reported from or known to occur in Porto Rico, together with the host plants or substrata on which the various species occur. For convenience of reference an index to the hosts is also given, as well as a list of such publications on island species as have been encountered.

It is very clearly realized that the species here listed do not by any manner of means represent the complete fungus flora of the Island. The list may rather be considered as a starting point for more intensive work, and it is hoped that the publication and distribution of this preliminary paper may stimulate interest among local collectors, and so bring about important additions to the list. It should be easily possible to double the number of species here reported. In fact, the working up of the undetermined material now in the herbarium of this Station will add considerably to the number of species known, and similarly the as yet unnamed portions of the collections of Dr. Stevens and other collectors give promise of many species new to the Island.

History of work with Porto Rican fungi.

The earliest recorded collection of the fungi of Porto Rico was made in 1854 by Carl Schwanecke, for the most part in the vicinity

[1] Exclusive of the lichens or algicolous fungi.

of Humacao, and the specimens were determined by Klotzsch, who listed them in Linnaea (50).[1] It was not until 1884–87 that further collections were made, during which period P. Sintenis visited various parts of the Island. The fungi gathered by him were worked over by J. Bresadola, P. Hennings, and P. Magnus and their determinations were published in 1893 (76). A recapitulation of these two lists was given by Heller (35) in 1900.

The work of these two collectors was apparently all that was accomplished during the time of Spanish sovereignty. As far as known to the writer the late Dr. Stahl made no mention of fungi in his writings, although he did serve at one time on a royal commission appointed to study a cane disease.

Since the change in government in 1898 the collecting and studying of the fungi has been carried on by workers connected with the experiment stations, and by a number of northern botanists who have made collecting trips to the Island.

Since the year 1903, the reports of the Federal Experiment Station at Mayagüez have contained references to various fungi from an economic standpoint. These have included notes by Barrett (6–9) on diseases of oranges, *yautía*, vegetables and other crops, by Henricksen (36) on diseases of vegetables, and by Fawcett (22–32) on diseases of coffee, sugar cane, citrus, banana, cacao, and vanilla. The latter has in addition to his annual reports as pathologist of the Station published a bulletin on coffee diseases (31), and a short article on *Pellicularia* (28). Some of the entomogenous fungi have been mentioned by Tower (100). A banana disease due to a vascular fungus parasite has been studied by Brandes (10, 11) of the same institution.

Work on the fungi as disease-producing agents of sugar cane was immediately taken up at the experiment station of the Sugar Producers' Association following its establishment in 1910. Reports of this work were issued from time to time as publications of the station (38–48). Following the transfer of the institution to the Insular Government, studies were begun on diseases of other crops in addition to the sugar-cane investigations. Results obtained have been issued in the various station publications prepared by the present pathologist (84–96). These have been concerned with diseases of citrus, vegetables, and minor economic plants.

The first of the American botanists to collect fungi, at least to any great extent, was A. A. Heller, who together with Mrs. Heller

[1] Figures in Parenthesis refer to "Literature cited," p. 250.

made an extensive collecting trip during the early part of 1900. The determinations of their specimens, including seventeen new species, were made by Prof. F. S. Earle (19). Some time later the same mycologist published additional notes on the same collection, for the most part as new species (21). Professor Earle himself (20) made a visit of exploration in 1903, giving most attention to fungi attacking economic plants.

Dr. G. P. Clinton, at the request of the Experiment Station, spent some time on the Island in 1904, in connection with a threatened outbreak of coffee rust, and collected some fungi, particularly the smuts. Prof. E. D. Holway collected rust fungi in about 1910. His specimens are reported upon by Dr. Arthur (3), in connection with the Stevens' collection.

Fungi have been collected to some extent on the various field expeditions of Dr. N. L. Briton, director-in-chief of the New York Botanical Garden, and members of his staff. These specimens have been described or mentioned in the publications of the mycologists of the Garden.

Dr. Bruce Fink of Miami University spent several months in 1915–16 collecting in various parts of the Island, giving particular attention to the lichens and Ascomycetes, but has as yet published only a preliminary paper (33). A report of his findings should very materially add to the number of known species.

During the same year Dr. E. W. Olive of the Brooklyn Botanic Garden, and Prof. H. H. Whetzel of Cornell University, made a very complete collection of the rusts, together with some other fungi. The rusts were worked over and reported by Dr. Arthur (4), and in part by themselves (71).

The most extensive fungus collections have been made by Dr. F. L. Stevens, now of the University of Illinois. These specimens were gathered during the period of his deanship of the College of Agriculture of Porto Rico and during one subsequent trip (79). The number of specimens obtained totaled several thousands. The rusts of this collection have been enumerated by Dr. Arthur (3), and Dr. Stevens and several of his students have worked on other groups (16, 17, 34, 51, 60, 61, 80, 81, 82, 83, 103, 104). Their studies have resulted in a very large number of species being reported as new, particularly in the genera *Meliola*, *Cercospora*, *Phyllosticta*, and *Mycosphaerella*.

An interesting phase of the subject of Porto Rican fungi, and one of no little importance, is that of species connected with certain human diseases. One article only has been seen treating of fungi

from this viewpoint, but there doubtless are others. Dr. King in the paper in question (49) mentions *Epidermophyton cruris* (*tinea cruris*), *Cladosporium Mansoni* (black ringworm), and *Malassezia tropica* (*tinea flava*), all causing skin diseases.

Acknowledgments.

Acknowledgment must be made for help received during the preparation of this list from a considerable number of sources. Several mycologists have worked over portions of the collections of the Insular Experiment Station and furnished determinations. These have included Dr. F. J. Seaver, and Dr. Wm. A. Murrill, New York Botanical Garden; Dr. E. A. Burt, Missouri Botanical Garden; Prof. C. G. Lloyd; Dr. W. C. Sturgis; and Dr. C. R. Orton, Pennsylvania State College. I am also indebted to Dr. Seaver for permission to use data from a preliminary list of the Porto Rican fungi deposited in the portion of the herbarium of the New York Botanical Garden under his charge, as well as for other favors. Drs. Burt, Sturgis, and Orton and Professor Lloyd have examined and made suggestions as to corrections in portions of the manuscript submitted to them. Mr. H. E. Thomas, formerly of the Mayagüez Experiment Station, has furnished information from his notes. From Dr. Olive and Professor Whetzel I have received a set of the specimens collected by them during their visit to the Island, in so far as the material has been worked up. This has afforded a considerable amount of additional data.

To Dr. Stevens of the University of Illinois I am particularly indebted for copies of his publications on Porto Rican fungi, and for the loan of a card index of fungi and hosts, based on his collections.

Plan of the work.

It is the aim of the present list to record the fungi reported as occurring in Porto Rico, together with the hosts or substrata, the localities in which they have been collected, the name of the respective collectors, and all bibliographical citations. When the collector has been other than a member of the staff of the Insular Experiment Station, past or present, his name is given in parenthesis following the localities. Semicolons, it will be noted, are used to separate the work of different collectors. Our own collections are cited first, followed by such others as have been made. Where more than one collection has been made in the same locality the earliest in point of

time is given as a rule. In some instances the first collection found in working up the list has been used.

Those who have made the collections represented in the herbarium of the Insular Experiment Station are Mr. John R. Johnston, pathologist 1910–1914, to whom credit is due for initiating not only the herbarium but the other botanical work of the Station; the writer, assistant pathologist 1913–14, pathologist and botanist to date; Mr. R. C. Rose, assistant pathologist 1916–17.

No attempt has been made at a critical study of the species listed. It is realized that many of those given will in the course of time be recombined, reduced to synonomy, or otherwise changed in name, but neither time nor facilities are available here for systematic work of this nature. The system of classification used is entirely one of convenience and has no other significance, either as a proposed new plan, or even as the personal views of the writer.

MYXOMYCETES.[1]

CERATIOMYXACEÆ.

CERATIOMYXA FRUCTICULOSA (Muell.) Macbr.
On rotten wood, Palo Seco.

PHYSARACEÆ.

PHYSARUM CINEREUM (Batsch.) Pers.
Fruiting on living leaves and stems of *Phaseolus vulgaris, Saccharum officinarum, Lactuca sativa, Vigna unguiculata*, and other plants, Río Piedras, Martín Peña, Manatí (48).

PHYSARUM COLUMBINUM (Rost.) Sturgis.
(*Tilmadoche compacta* [Wing.] McB.) (82).
On rotten wood, Río Piedras.

PHYSARUM COMPRESSUM Alb. & Schw.
On Sugar-cane debris, Cortada (48).

PHYSARUM DIDERMOIDES (Ach.) Rost.
On rotten wood, Río Piedras.

PHYSARUM PUSILLUM (B. & C.) List.
(*Physarum nodulosum* [Cooke & Balf.] Mass.)
On rotten sacking, and also found fruiting on living sugar-cane leaves, Río Piedras (48).

PHYSARUM VIRIDE (Bull.) Pers.
On rotten wood, Moca, Río Piedras.

[1] The determinations in this group were made for the most part by Dr. William C. Sturgis.

FULIGO SEPTICA (L.) Gmel.

(*Fuligo ovata* [Schaeff.] Macbr.) (48).

On dead cane leaves, banana debris, rotten wood, Pueblo Viejo, Sabana Llana, Río Piedras, Juana Díaz (48).

CRATERIUM AUREUM (Schüm.) Rost.

On humus and cane trash, fruiting at times on living stalks and leaves, Ponce, Río Piedras (48).

CRATERIUM LEUCOCEPHALUM (Pers.) Ditm.

On dead leaves and debris, fruiting at times on living sugar-cane leaves, Pueblo Viejo, Río Piedras (48).

DIDERMA EFFUSUM (Schw.) Morg.

On dead leaves of *Pandanus utilis*, Río Piedras.

DIDERMA SPUMARIOIDES Fr.

On dead leaves and rotten wood, Martín Peña.

DIACHÆA LEUCOPODA (Bull.) Rost.

var. GLOBOSA List.

On dead grass and leaves, Río Piedras. Reported by Stevens on *Pitcairnia angustifolia*, Naguabo, Sta. Ana (82).

DIDYMIACEÆ.

DIDYMIUM NIGRIPES (L.) Fr.

Fruiting on living leaves of *Wedelia trilobata*, and *Commelina nudiflora*, Pueblo Viejo, Río Piedras.

STEMONITACEÆ.

COMATRICHA LANGA Peck.

On dead wood, Porto Rico (Stevens) (82).

STEMONITIS FUSCA Roth.

On sugar-cane trash, Río Piedras (48).

STEMONITIS HERBATICA Pk.

On rotten wood, Pueblo Viejo.

STEMONITIS SPLENDENS Rost.

On rotten wood and cane trash, Río Piedras, Martín Peña, Vega Baja (48).

CRIBRARIACEÆ.

DICTYDIUM CANCELLATUM (Batsch.) Macbr.

On dead sugar-cane leaves and stalks, Río Piedras (48).

TUBULINACEÆ.

TUBIFERA FERRUGINOSA (Batsch.) Gmel.

On rotten wood, Palo Seco.

LYCOGALACEÆ.

LYCOGALA EPIDENDRUM (L.) Fr.
On rotten wood and sugar-cane trash, Río Piedras, El Duque (48).

ARCYRIACEÆ.

ARCYRIA DENUDATA (L.) Sheld.
On rotten wood and sugar-cane trash, Río Piedras, Martín Peña, (48).

ARCYRIA CINEREA (Bull.) Pers.
On rotten wood and sugar-cane trash, Río Piedras, Pueblo Viejo (48).

ARCYRIA PUNICEA Pers.
Reported from Fajardo in the Schwanecke collection (50).

TRICHIACEÆ.

HEMITRICHIA VESPARIUM (Batsch.) Macbr.
On rotten wood, Río Piedras.

HEMITRICHIA CLAVATA (Pers.) Rost.
On rotten wood, Martín Peña.

SCHIZOMYCETES.

COCCACEÆ.

MICROCOCCUS NIGROFACIENS Northrup.
Causing a disease of various stages of *Phyllophaga* spp., Río Piedras, Guánica (69, 78).

BACTERIACEÆ.

BACILLUS CAROTOVORUS Jones.
Producing a soft rot of carrots, cabbages, celery, and other vegeables, Río Piedras.

BACILLUS MESENTERICUS (Flügge) L. & N.
Causing "ropy" bread, Río Piedras, San Juan.

BACILLUS PRODIGIOSUS (Ehr.) L. & N.
Occasional as a contamination of cultures, Río Piedras.

BACILLUS RADICICOLA Bey.
Common on a wide range of leguminous hosts.

BACILLUS SUBTILIS (Ehr.) Cohn.
Common as a contamination in poured plates, Río Piedras.

BACTERIUM CAMPESTRIS Pamm.
On *Brassica oleracea*, Mayagüez (Thomas) (36, 90).

BACTERIUM PHASEOLI Er. Sm.
On *Phaseolus vulgaris*. Causes a serious leaf and pod disease, Río Piedras (90, 94).

BACTERIUM SOLANACEARUM Er. Sm.
Causing a serious wilt disease of *Lycopersicum esculentum*, *Solanum melongena*, *Nicotiana tabacum*, *Solanum tuberosum*, Río Piedras. A wilt disease of *Helianthus annuus*, probably attributable to this species reported by Thomas (15, 36, 56, 77, 90, 94).

PHYCOMYCETES.

CHYTRIDIACEÆ.

OLPIDIELLA UREDINIS Lagerh.
On *Puccinia levis* on *Rytilix granularis* (*Manisuris granularis*), Maricao (Sintenis) (76).

SYNCHYTRIUM DECIPIENS Farl.
On *Rhynchosia reticulata*, Palo Seco; Quebradillas, Cabo Rojo (Stevens) (82).

PERONOSPORACEÆ.

ALBUGO BLITI (Biv.) Kuntze.
On *Amaranthus viridis*, Río Piedras, Barceloneta.
Amaranthus spinosus, Barceloneta (82, 101).

ALBUGO CANDIDA (Pers.) Kuntze.
On *Brassica integrifolia*, Río Piedras.
Brassica japonica, Barranquitas.
Lepidium virginicum, Comerío, Bayamón; Río Tanamá (Stevens) (82).

ALBUGO IPOMŒÆ-PANDURANÆ (Schwein.) Swingle.
On *Ipomœa* sp., Espinosa; Río Piedras, Peñuelas, Mona (Stevens).
Ipomœa batatas, Río Piedras, Vega Baja, Pueblo Viejo; Monte de Oro, Río Tanamá, Consumo, Arecibo, Manatí, Corozal, Luquillo, Boquerón, Guánica, Guayanilla (Stevens) (82, 90, 94).
Ipomœa pes-capræ, Cataño, Punta Cangrejos; Dos Bocas, Guánica, Boquerón, Mayagüez (Stevens) (82).
Ipomœa pes-tigridis, Guayama.
Ipomœa rubra, Río Piedras.

ALBUGO IPOMŒÆ-PANDURANÆ (Schwein.) Swingle—*Continued.*
On *Ipomœa tiliacea*, Garrochales, Río Piedras; San Germán (Stevens).
Jacquemontia nodiflora, Guayanilla, Mona Island (Stevens) (82).
Jacquemontia pentantha, Vega Baja.
Thyella tamnifolia, Río Piedras (101).

ALBUGO PLATENSIS (Speg.) Swing.
On *Bœrhaavea erecta*, Guánica (Stevens) (82).
Bœrhaavea hirsuta (Goll.) (101).
Bœrhaavea panniculata, Culebra (Britton).

ALBUGO PORTULACÆ (D. C.) Kuntze.
On *Portulaca oleracea*, Mayagüez (Stevens) (82).

PERONOPLASMOPORA CUBENSIS (B. & C). Clint.
On *Cucumis melo*, Río Piedras, Mayagüez (36, 90, 94).
Cucumis sativus, Río Piedras, Mayagüez.
Cucurbita moschata, Río Piedras, Mayagüez.
Luffa cylindrica, Río Piedras (Stevens) (82).

PHYTOPHTHORA INFESTANS (Mont.) De Bary.
On *Lycopersicum esculentum*, Mayagüez; Maricao (W. & O.) (36, 90, 94).
Solanum tuberosum, Mayagüez (Thomas).

PHYTOPHTHORA PHASEOLI Thax.
On *Phaseolus lunatus*. Reported by Henricksen (36).

PHYTOPHTHORA TERRESTRIA Sherb.
On *Capsicum annuum*, Río Piedras.
Lycopersicum esculentum, Río Piedras, San Juan.
Phaseolus vulgaris, Río Piedras (90, 94).
The cause of a serious disease of beans and tomatoes.

MUCORACEÆ.

CHOANEPHORA CUCURBITARUM (Berk. & Rav.) Thax.
On *Hibiscus esculentus*, Río Piedras. Causing a disease of the flowers and young pods.

PILOBOLUS CRYSTALLINUS Tode.
On horse manure, Río Piedras.

RHIZOPUS NIGRICANS Ehr.
Producing a soft rot of sweet potatoes, also as a bread mold, and contamination in cultures, Río Piedras (89, 96).

ENTOMOPHTHORACEÆ.

EMPUSA FRESENII Now.

On *Pseudococcus nipa* on *Chrysophyllum argenteum*, Río Piedras.

on *Acalypha Wilkesiana*, Río Piedras.

on *Erythrina glauca*, Río Piedras.

Phenococcus sp., on *Psidium guayaba*, Río Piedras (46).

EMPUSA SPHÆROSPERMA (Fres.) Thaxt.

On *Laphygma frugiperda*, Río Piedras (46).

ENTOMOPHTHORA AULICÆ Reich.

On *Ecpantheria eridanus*, Naguabo, Río Piedras (46).

ASCOMYCETES.

SACCHAROMYCETACEÆ.

SACCHAROMYCES APICULATUS Reess.

Isolated from fermenting cacao and coffee (Loew) (57).

SACCHAROMYCES CEREVISIÆ Hansen.

Bread and brewer's yeast.

SACCHAROMYCES ELLIPSOIDEUS Hansen.

Isolated from fermenting cacao and coffee (Loew.) (57), and fermented grapefruit juice, Río Piedras.

PHYMATOSPHÆRIACEÆ.

MYRIANGIUM DURLEI Mont. & Berk.

On *Aulacaspis pentagona* on *Solanum rugosum*, Río Piedras, on *Cajanus indicus*, Sabana Llana.

Hemichionaspis minor on undet. vine, Palo Seco.

Howardia biclavis on *Guettarda scabra*, Río Piedras.

Lepidosaphes beckii, and *Chionaspis citri* on *Citrus* spp., Sabana Llana, Río Piedras, Pueblo Viejo, Bayamón, Santurce, Espinosa, Vega Baja, Garrochales.

Very common everywhere on scale insects, parasitic to some extent at least (20, 46, 96, 100).

ERYSIPHACEÆ.[1]

ERYSIPHE CICHORACEARUM D. C. (?).

On *Cosmos caudatus*, Sta. Ana, Río Tanamá (Stevens).

Eupatorium microstemum, Maricao (Stevens).

Solanum torvum, Rosario, Naguabo, Cabo Rojo, Maricao, Arecibo, Peñuelas, Mayagüez (Stevens) (82).

[1] All determinations in this faimly are provisional only, the conidial or *Odium* stage only having been found in all cases.

ERYSIPHE GALEOPSIDIS D. C. (?).
On *Eupatorium* sp., Ponce (Stevens) (82).

ERYSIPHE POLYGONI D. C. (?).
On *Arracacia xanthorrhiza*, Indiera Fría (Stevens).
Cassia occidentalis, Guayama, Río Piedras, Rosario, Peñuelas, Arecibo-Lares, Cabo Rojo, Manatí (Stevens).
Cassia tora, Palo Seco: Maricao, Quebradillas, Aguada, Peñuelas, Guayanilla, San Germán, Guayama, Adjuntas, Mayagüez (Stevens).
Chamæcrista æschynomene, Palo Seco.
Chamæcrista diphylla, Espinosa.
Chamæcrista sp., Peñuelas (Stevens).
Dolicholus minima, Carolina.
Dolichos biflorus, Río Piedras.
Phaseolus adenanthus, Aguada (Stevens).
Phaseolus max, Río Piedras.
Phaseolus vulgaris, Río Piedras.
Pisum sativum, Río Piedras.
Vigna repens, Mayagüez (Stevens) (82).
Vigna unguiculata, Río Piedras (90, 94).

MICROSPHÆRA DIFFUSA D. C. (?).
On *Crotalaria retusa*, Sta. Ana, Coamo (Stevens).
Meibomia sp., Rosario, Mona Island (Stevens).
Meibomia adscendens, Utuado (Stevens).
Meibomia scorpiurus, Manatí, Guayama (Stevens).
Meibomia supina, Utuado, Jayuya (Stevens).
Meibomia tortuosa, Sabana Llana, Río Piedras: Peñuelas, (Stevens) (82).

MICROSPHÆRA EUPHORBIÆ (Pk.) B. & L. (?).
On *Chamæsyce braziliensis*, Mona Island (Stevens).
Chamæsyce hypericifolia, Mona Island, Jájome Alto (Stevens).
Hibiscus sabdariffa, Mayagüez (Stevens).
Manihot manihot, Río Piedras (Stevens) (82).

SPHÆROTHECA HUMULI (D. C.) Burr. (?).
On *Bidens leucantha*, Palo Seco.
Bidens reptans, Vega Baja, Maricao (Stevens) (82).
Cosmos sp., Jayuya (Stevens).
Melanthera canescens, Utuado (Stevens).
Ocimum micranthum, Utuado (Stevens).
Rosa sp., Maricao (Stevens).
Verbena sp., Maricao (Stevens).

PERISPORIACEÆ.

ANTENNULARIA (?) TENUIS Earle.

On *Musa* sp., and *Inga vera* (Heller) (21).

CAPNODIUM CITRI Berk. & Desm.

On *Citrus decumana*, Sabana Llana, Espinosa, Campo Alegre, Pueblo Viejo, Vega Baja (96).

DIMERIELLA CORDIÆ (P. Henn.) Th.

On *Cordia sulcata*, Mayagüez (Stevens) (82).

DIMERIELLA ERIGERONICOLA Stevens.

On *Erigeron pusillum*, Maricao (Stevens).

Erigeron spathulatus, Quebradillas, Maunabo, Yauco, El Gigante, Maricao (Stevens) (82).

Leptilon canadense, Río Piedras, Trujillo Alto, Vega Baja, Camuy, Arecibo.[1]

DIMERIELLA OLYRÆ Stevens.[1]

On *Olyra latifolia*, Río Piedras, Preston's Ranch, Maricao, Mayagüez (Stevens) (82).

DIMERINA JACQUINIÆ Garman.

On *Jacquinia barbasco*, Mona Island (Stevens) (34).

DIMERIOPSIS ARTHROSTYLIDICOLA Stevens.

On *Arthrostylidium sarmentosum*, Monte Alegrillo (Stevens) (82).

DIMERIUM CAYAPONIÆ Garman.

On *Cayaponia americana*, Utuado (Stevens) (34).

DIMERIUM GRAMMODES (Kuntze) Gar.

On *Crotalaria retusa*, Trujillo Alto, Pueblo Viejo; Guayama, Cabo Rojo (Stevens). From Mayagüez as *Parodiella perisporioides* (Heller collection) (19).

Meibomia adscendens, Río Piedras.

Meibomia barbata, Río Piedras (Stevens); Añasco (W. & O.) (82).

Meibomia sp., Espinosa, Río Piedras.

Phaseolus lunatus, Aguadilla (Stevens).

Phaseolus vulgaris, Río Piedras (81).

Vigna repens, Río Piedras (34).

[1] In comparing the descriptions, the great similarity between those of *Dimeriella Olyrae* and *Asterina fumagina* was noted. In response to a request for an opinion in the matter, Dr. Stevens replied as follows:

"The species as published by Dearness and Barth. is based upon specimen No. 190 of my collection. My species, *Dimeriella olyrae*, is based upon my specimen No. 6770, but the two are co-specific and the publication of Dearness & Barth. clearly has the priority.

"In the light of modern publications on this group, I believe that this fungus should be placed in the genus *Dimeriella* of Spegazzini, and therefore suggest the following:

"*Dimeriella fumagina* (Dearn. a Barth.) Stevens, comb. nov.

"(*Asterina fumagina* Dearn & Barth.)

"(*Dimeriella olyrae* Stevens.)"

DIMERIUM MELIOLOIDES (Berk. & Curt.) Gar.
On *Clusia rosea*, Maricao (Stevens) (34).

DIMERIUM STEVENSII Garman.
On *Cordia corymbosa*, Río Piedras: Quebradillas, Mayagüez, Maricao (Stevens) (34).

DIMEROSPORIUM APPENDICULATUM Earle.
On *Asterina sidæ* on *Sida carpinifolia* (21).

DIMEROSPORIUM TROPICALE Speg.
On *Meliola* sp., on *melastomaceous* plant. Col. N. Y. Bot. Garden.

EUROTIUM ARGENTINUM Speg.
On dead sugar-cane stalks, Río Piedras (48).

EUROTIUM HERBARIUM Lk.
On dried herbarium specimens, Río Piedras.

HYALODERMA PILIFERUM Pat.
On *Meliola* on a grass, Santurce. Coll. N. Y. Bot. Garden (82).

MELIOLA AIBONITENSIS Stevens.
On *dicotyledonous* plant, Aibonito (Stevens) (80).[1]

MELIOLA AMBIGUA Pat. & Gaill.
On *Lantana camara*, Dos Bocas, below Utuado, Río Arecibo (Stevens).
Lantana odorata, Quebradillas (Stevens).
Lantana sp., Quebradillas, Dos Bocas (Stevens).

MELIOLA AMOMICOLA Stevens.
On *Amomis caryophyllata*, Mayagüez (Stevens).

MELIOLA AMPHITRICA Fr.
On *Randia aculeata* (?), Caguas (Heller collection).
Tetragastris balsamifera (*Hedwigia balsamifera*). Sintenis collection (76).

MELIOLA ANDIRÆ Earle.
On *Andira jamaicensis*, Camuy, Mayagüez: Arecibo, Martín Peña, Yauco, Santana, Maricao, Dos Bocas, Vega Alta, Lares, Manatí (Stevens) (21).

MELIOLA ARECIBENSIS Stevens.
On *Acalypha bisetosa*, Vega Baja, Dos Bocas (Stevens).

MELIOLA BICORNIS Wint.
On *Bradburya pubescens*, Espinosa.
Bradburya virginiana, Arecibo-Lares Road, Manatí, Dos Bocas, Vega Baja, Quebradillas (Stevens).

[1] Since all species of Meliola known to the Island are treated in Dr. Steven's paper, "The Genus Meliola in Porto Rico," further citations to it are omitted.

MELIOLA BICORNIS Wint.—*Continued.*

On *Dalbergia monetaria*, Mayagüez, Arecibo-Lares, Maricao (Stevens).

Dalbergia sp., Mayagüez, Rosario (Stevens).

Dolicholos reticulatus, Río Piedras; Florida Adentro, Vega Baja, Lares, Quebradillas, Barceloneta, Río Tanamá (Stevens).

Erythrina mycropteryx, El Miradero (Stevens).

Lonchocarpus glaucifolius, Quebradillas (Stevens).

Meibomia adscendens, Río Piedras: El Alto de la Bandera (Stevens).

Meibomia axillaris, Río Piedras: Florida Adentro, Las Marías, Mayagüez, Río Arecibo, Río Tanamá (Stevens).

Meibomia supina, Cataño, Martín Peña, Maricao, Vega Baja, Mayagüez, Florida Adentro, Río Tanamá, Dos Bocas, El Gigante, Indiera Fría (Stevens).

Mimosa ceratonia, Maricao, Río Arecibo, Vega Baja, Aibonito (Stevens).

Teramnus uncinatus, Maricao, Añasco (Stevens) (21).

MELIOLA BICORNIS var. CALOPOGONII Stevens.

On *Calopogonium orthocarpum*, Río Piedras; Dos Bocas, Mayagüez, Aguada (Stevens).

MELIOLA BICORNIS var. GALACTIÆ Stevens.

On *Galactia dubia*, Río Tanamá (Stevens).

MELIOLA BIDENTATA Cke.

On *Tabebuia haemantha*, Monte Alegrillo (Stevens).

Tecoma pentaphylla, Guanajibo (Stevens).

MELIOLA BYRSONIMÆ Stevens.

On *Brysonima lucida*, Guayanilla (Stevens).

MELIOLA CALOPHYLLI Stevens.

On *Calophyllum calaba*, Mayagüez, Vega Baja (Stevens).

MELIOLA CAPSICOLA Stevens.

On *Capsicum baccatum*, Manatí, Dos Bocas (Stevens).

MELIOLA CHAMÆCRISTÆ Earle.

On *Chamaecrista glandulosa* (Heller). Coll. N. Y. Bot. Garden (21).

MELIOLA CHAMÆCRISTICOLA Stevens.

On *Chamaecrista granulata*, Mona Island (Stevens).

MELIOLA CHIOCOCCÆ Stevens.

On *Chiococca alba*, Vega Baja, Hormigueros (Stevens).

MELIOLA CIRCINANS Earle.

On *Mariscus jamaicensis*, Martín Peña; San Juan, Manatí (Stevens) (21).

Rynchospora aurea, Martín Peña (Heller).

Rynchospora gigantea, Martín Peña.

MELIOLA CLAVULATA Wint.

On *Ipomœa batatas*, Río Piedras; Vega Baja, Río Tanamá, Maricao (Stevens) (90).

Ipomœa cathartica, Río Arecibo, Vega Baja, El Alto de la Bandera (Stevens).

Ipomœa rubra, Río Piedras, Guaynabo.

Ipomœa tiliacea, Mayagüez (Stevens).

Ipomœa sp., Río Piedras, Espinosa; Sabana Llana, San Germán, Monacillo, Trujillo Alto, El Miradero, Mayagüez, Vega Alta (Stevens).

MELIOLA CLUSLÆ Stevens.

On *Clusia minor*, El Alto de la Bandera (Stevens).

MELIOLA COMOCLADLÆ Stevens.

On *Comocladia glabra*, Rosario, Mayagüez, Maricao (Stevens).

Spondias mombin, Maricao (Stevens).

MELIOLA COMPACTA Earle.

On *Crossopetalum pallens*. Coll. N. Y. Bot. Garden (21).

MELIOLA COMPOSITARUM Earle.

On *Eupatorium odoratum*, Trujillo Alto, Río Piedras; Dos Bocas, Rosario, Maricao, Aibonito, Utuado, El Gigante, El Miradero, Las Marías; Río Tanamá, Mayagüez, Yauco, Cataño, Jájome Alto (Stevens).

Eupatorium sp., Río Piedras, (Heller).

Willoughbaea sp., Adjuntas (Heller).

MELIOLA COMPOSITARUM var. *portoricensis* Stevens.

On *Eupatorium dolicholepis*, Río Tanamá (Stevens).

Eupatorium portoricensis, Camuy; Vega Baja, Dos Bocas, San Sebastián, Arecibo-Lares (Stevens).

MELIOLA CONTORTA Stevens.

On *Piper hispidum*, Las Marías (Stevens).

MELIOLA CUCURBITACEARUM Stevens.

On Cucurbit, undet., El Alto de la Bandera (Stevens).

MELIOLA CUPANLÆ Stevens.

On *Cupania americana*, El Miradero (Mayagüez), Maricao, Dos Bocas, Quebradillas (Stevens).

Cupania sp., Quebradillas (Stevens).

MELIOLA CYCLOPODA Stevens.
On *Pseudelephantopus spicatus,* Vega Baja (Stevens).

MELIOLA CYPERI Pat.
On *Cyperus* sp., Mayagüez (Stevens).
Mariscus jamaicensis, San Juan (Stevens); Martín Peña (W. & O.).
Scleria sp., Manatí (Stevens).

MELIOLA DENTICULATA Wint.
On *Roystonea borinquena,* Arecibo-Lares (Stevens).

MELIOLA DIDYMOPANICIS P. Henn.
On *Dendropanax arboreum,* Manatí; Río Arecibo, Mayagüez (Stevens).
Dendropanax laurifolium, El Alto de la Bandera (Stevens).

MELIOLA DIEFFENBACHIÆ Stevens.
On *Dieffenbachia seguine,* Río Piedras, Espinosa; Las Marías, Maricao, Cataño, Lajas, Monte de Oro, Dos Bocas, Mayagüez (Stevens).

MELIOLA DIPHOLIDIS Stevens.
On *Dipholis salicifolia,* Guayanilla, Quebradillas (Stevens).

MELIOLA EARLII Stevens.
On *Pilea nummularifolia,* Espinosa; Jájome Alto (Stevens).
Pilea parietaria, Río Arecibo (Stevens).
Pilea sp., Florida Adentro (Stevens).

MELIOLA FURCATA Lev.
On *Acrista monticola,* El Alto de la Bandera, Luquillo Forest (Stevens).
Coccothrinax alta, Dos Bocas (Stevens).
Macrodiscus lactiflorus, Coamo (Stevens).
Thrinax ponceana, Guayanilla (Stevens) (81).
Thrinax praeceps, Dos Bocas (Stevens).

MELIOLA GAILLARDIANA Stevens.
On *Piper aduncum,* Río Arecibo, Dos Bocas, Las Marías (Stevens).

MELIOLA GESNERIÆ Stevens.
On *Cestrum laurifolium,* Maricao (Stevens).
Cestrum macrophyllum, El Alto de la Bandera, El Gigante (Stevens).
Gesneria albiflora, Mayagüez, Dos Bocas (Stevens).

MELIOLA GLABRA Berk. & Curt.
On *Drypetes* spp., Río Tanamá (Stevens).
Hypelate trifoliata, Mona (Britton).

MELIOLA GLABRA var. *psychotriæ* Stevens.

On *Coccocypselum repens*, Maricao (Stevens).

Palicourea domingensis, Florida Adentro (Stevens).

Palicourea sp., Mayagüez, Vega Baja, Utuado, Ponce, Maricao, El Gigante (Stevens).

Psychotria bertiana, El Alto de la Bandera (Stevens).

Psychotria grandis, Mayagüez (Stevens).

Psychotria pubescens, Arecibo-Lares Road, Vega Baja (Stevens).

Psychotria sp., Quebradillas (Stevens).

MELIOLA GLABROIDES Stevens.

On *Nectandra patens*, Mayagüez, Maricao (Stevens).

Piper aduncum, Indiera Fría, El Alto de la Bandera, Las Marías, Dos Bocas, Vega Baja, Mayagüez, Añasco, Maricao, Arecibo-Lares Road, Aibonito, Lares, Martín Peña, Trujillo Alto, Utuado (Stevens) (19).

Piper marginatum, Espinosa.

Sauvagesia erecta, El Alto de la Bandera, Las Marías, Maricao (Stevens).

Simaruba tula, Mayagüez, El Gigante (Stevens).

Solanum persicifolium, Quebradillas, (Stevens).

Solanum rugosum, Las Marías (Stevens).

Valerianodes cayennensis, Río Piedras; Sabana Llana, Trujillo Alto (Stevens).

MELIOLA GLABROIDES var. SCHLEGELIÆ Stevens.

On *Schlegelia* sp., El Alto de la Bandera (Stevens).

MELIOLA GUAREÆ Speg.

On *Guarea trichilioides*, Las Marías, Dos Bocas, Monte de Oro, Adjuntas, Jájome Alto, Mayagüez (Stevens).

MELIOLA GUAREICOLA Stevens.

On *Guarea trichilioides*, Las Marías, Mayagüez, Adjuntas, Monte de Oro, Dos Bocas (Stevens).

MELIOLA GUIGNARDI Gaill.

On *Turpinia panniculata*, Maricao (Stevens).

MELIOLA GYMNANTHICOLA Stevens.

On *Gymnanthes lucida*, Guayanilla (Stevens).

MELIOLA HELLERI Earle.

On *Eugenia monticola*, Manatí (Stevens).

Eugenia Stahlii, Luquillo, El Alto de la Bandera (Stevens).

Myrcia deflexa, El Alto de la Bandera (Stevens).

Myrcia splendens, Jájome Alto (Stevens).

Unknown woody plant (Heller) (21).

MELIOLA HESSII Stevens.
On *Paullinia pinnata*, Sabana Llana, Mayagüez (Stevens).
MELIOLA HYPTIDICOLA Stevens.
On *Hyptis atrorubens*, Río Piedras.
Hyptis capitata, El Gigante (Stevens).
Hyptis lantanifolia, Las Marías (Stevens).
Hyptis pectinata, Dos Bocas, Maricao (Stevens).
Hyptis sp., Monte de Oro (Stevens).
MELIOLA IPOMŒÆ Earle.
On *Ipomœa batatas*, Río Piedras, Garrochales.
Ipomœa cathartica, Las Marías, Vega Baja (Stevens).
Ipomœa tiliacea, Añasco, Mayagüez (Stevens).
Ipomœa spp., El Miradero, Dos Bocas, Rosario, Maricao (Stevens); Mayagüez (Heller) (19, 90).
MELIOLA IRREGULARIS Stevens.
On *Hygrophila brasiliensis*, Río Piedras (Stevens).
MELIOLA JATROPHÆ Stevens.
On *Jatropha hernandifolia*, Río Tanama, Dos Bocas (Stevens).
MELIOLA LAGUNCULARIÆ Earle.
On *Conocarpus erecta*, Mayagüez (Stevens) (82).
Laguncularia racemosa, Martín Peña, Mayagüez, Joyuda (Stevens); Cataño (Heller) (19).
MELIOLA LONGIPODA Gaill.
On *Anona montana*, Mayagüez (Stevens).
Cordia corymbosa, Río Piedras.
Cordia nitida, Martín Peña (Stevens).
Cordia sp., Mayagüez (Stevens).
Tournefortia hirsutissima, Martín Peña, Sabana Llana; Arecibo, Dos Bocas, Quebradillas (Stevens).
MELIOLA LUCUMÆ Stevens.
On *Lucuma multiflora*, Las Marías, Guayanilla (Stevens).
MELIOLA MAGNOLIÆ Stevens.
On *Magnolia portoricensis*, Monte Alegrillo (Stevens).
MELIOLA MANCA Ell. & Mart.
On *Myrica cerifera*, Río Piedras; Manatí (Stevens); Cataño (Heller).
MELICOLA MANGIFERÆ Earle.
On *Mangifera indica*, Bayamón, Camuy; Mayagüez, Vega Baja, Manatí, Luquillo Forest, El Gigante (Stevens); Río Piedras (Heller) (21, 82).
MELIOLA MARICÆNSIS Stevens.
On *Ilex nitida*, Maricao (Stevens).

Meliola mayaguesiana Stevens.
On *Palicourea crocea*, Río Piedras; Las Marías, Lajas (Stevens).
Palicourea domingensis, Las Piedras (Stevens).
Palicourea riparia, Mayagüez (Stevens).
Palicourea sp., Mayagüez (Stevens).

Meliola mayepeæ Stevens.
On *Mayepea domingensis*, Mayagüez, El Alto de la Bandera (Stevens).

Meliola Mayepeicola Stevens.
On *Mayepea domingensis*, Mayagüez, Maricao (Stevens).

Meliola melastomacearum Speg.
On *Clidemia hirta*, Maricao, Mayagüez, Las Marías, Dos Bocas (Stevens).
Clidemia strigillosa, Trujillo Alto, Lajas (Stevens).
Heterotrichum cymosum, Utuado (Stevens) (82).
Miconia impetiolaris, Mayagüez (W. & O.).
Miconia lævigata, Río Piedras, Camuy; Dos Bocas, Arecibo (Stevens).
Miconia racemosa, Río Piedras; Mayagüez, Lajas (Stevens).

Meliola Merrillii Syd.
On *Cissus sicyoides*, Mayagüez, Camuy, Río Piedras; Lares, San Germán, Utuado, Villa Alba, El Gigante, Dos Bocas, Añasco, Aguada, Yauco, Manatí, Río Tanamá (Stevens).

Meliola miconiæ Stevens.
On *Miconia prasina*, Las Piedras, Las Marías (Stevens).

Meliola miconiicola Stevens.
On *Miconia Sintenisii*, El Alto de la Bandera (Stevens).

Meliola molleriana Wint.
On *Sida urens*, Río Piedras, Quebradillas; Aguada, Mayagüez, San Germán, Añasco, Yauco, Cataño, Santana, Dos Bocas, Arecibo-Lares, Las Marías, Rosario, El Miradero (Stevens).
Varronia sp., Las Marías, El Miradero, Mayagüez, El Alto de la Bandera (Stevens).

Meliola monensis Stevens.
On *Amyris elemifera*, Mona Island, Guayanilla (Stevens).

Meliola myrsinacearum Stevens.
On *Ardisia guadalupensis*, Mayagüez (Stevens).
Myrsinaceæ undet., Maricao (Stevens).

Meliola nigra Stevens.
On *Laguncularia racemosa*, Guanajibo, Joyuda (Stevens).

MELIOLA OCOTEAE Stevens.

On *Ocotea leucoxylon*, Jájome Alto (Stevens): Maricao (W. & O.).

MELIOLA OCOTEICOLA Stevens.

On *Chrysophyllum*, Monte Allegrillo (Stevens).

Ocotea leucoxylon, Mayagüez, Monte Allegrillo (Stevens).

MELIOLA PANICI Earle.

On *Andropogon bicornis*, Las Marías, Vega Baja (Stevens).

Andropogon leucostachyus, El Alto de la Bandera (Stevens).

Chloris petraea, Mayagüez (Stevens).

Ichnanthus pallens, Maricao, Monte de Oro, Mayagüez (Stevens); El Yunque (W. & O.).

Lasiacis divaricata, Río Piedras; Arecibo, Manatí, Vega Baja, Vega Alta (Stevens).

Lasiacis Sloanei (*Panicum latifolium*), Río Piedras; Santurce (Heller) (19).

Lasiacis ruscifolia (*L. compacta*), Utuado (Stevens).

Lasiacis sorghoidea (*L. swartziana*), Añasco, Las Marías (Stevens).

Olyra latifolia, El Miradero, Mayagüez, Maricao, San Germán, Arecibo (Stevens).

Oplismenus setarius, Maricao (Stevens).

Panicum glutinosum, Maricao, Monte de Oro, Utuado, El Alto de la Bandera, Ponce, El Gigante, Las Marías (Stevens).

Paspalum secans, Maricao (Stevens).

MELIOLA PARATHESICOLA Stevens.

On *Parathesis serrulata*, Las Marías, Maricao, Arecibo-Lares (Stevens).

MELIOLA PAUCIPES Stevens.

On *Piper blattarum*, Mayagüez (Stevens).

MELIOLA PAULLINIAE Stevens.

On *Casearia aculeata*, Lajas (Stevens).

Casearia arborea, Monte de Oro (Stevens).

Casearia guianensis, Río Piedras.

Casearia ramiflora, Martín Peña, Barceloneta, Manatí, Vega Baja, Santana, San Germán (Stevens).

Casearia sylvestris, Río Piedras; Mayagüez, Miradero, Arecibo-Lares, San Germán (Stevens).

Casearia sp., Martín Peña, Espinosa; Dos Bocas, Mayagüez (Stevens).

MELIOLA PAULLINIÆ Stevens—*Continued.*

On *Mammea americana*, Maricao, Las Marías (Stevens).

Mammea americana, Maricao, Las Marías (Stevens)

Paullinia pinnata, Río Piedras: Mayagüez, Río Arecibo, Vega Baja, El Alto de la Bandera, Barros (Stevens).

MELIOLA PERSEÆ Stevens.

On *Persea gratissima*, Las Marías (Stevens).

MELIOLA PHILODENDRI Stevens.

On *Philodendron krebsii*, Arecibo-Lares, Jayuya, Ponce, Jájome Alto, Maricao, El Alto de la Bandera (Stevens).

MELIOLA PILOCARPI Stevens.

On *Pilocarpus racemosus*, Mayagüez (Stevens).

MELIOLA PIPERIS Earle.

On *Piper aduncum*, Río Piedras: Dos Bocas, Las Marías, Maricao, Monte de Oro (Stevens): Mayagüez (Heller) (19).

MELIOLA PRÆTERVISA Gaill.

On *Coccoloba pyrifolia*, Mayagüez, Jájome Alto (Stevens).

Coccoloba sintenisii, Mayagüez (Stevens).

Coccoloba sp., Martín Peña: Jájome Alto (Stevens).

Cupania americana, Manatí: Mayagüez (Stevens).

MELIOLA PSIDII Fr.

On *Psidium guayaba*, Bayamón, Río Piedras; Yauco, San Germán, Mayagüez, San Sebastián, Vega Alta, Jájome Alto, Arecibo-Lares, Dos Bocas, Vega Baja, Sabana Llana, Maricao, Utuado, Jayuya (Stevens) (19).

MELIOLA PSYCHOTRIÆ Earle.

On *Borreria lævis*, El Alto de la Bandera, Dos Bocas (Stevens).

Borreria ocimoides (Stevens).

Chiococca alba, Río Piedras: Mayagüez, Río Tanamá (Stevens).

Erithalis fruticosa, Quebradillas, Mona Island, Guayanilla (Stevens) (21).

Gonzalagunia spicata, Sabana Llana, El Miradero, Mayagüez, Vega Baja, Río Arecibo (Stevens).

Guettarda ovalifolia, Maricao (Stevens).

Guettarda scabra, Martín Peña.

Mitracarpus portoricensis, Río Piedras.

Psychotria sp., Martín Peña.

Randia aculeata, Martín Peña, Río Piedras: Quebradillas, Florida Adentro, Hormigueros, Monacillo (Stevens).

Meliola pteridicola Stevens.
On *Adiantum latifolium*, Las Marías, Mayagüez (Stevens).
Adiantum sp., Mayagüez (Stevens).
Ancimia adiantifolia, Río Tanamá, Quebradillas, Dos Bocas (Stevens).
Ancimia spp., Dos Bocas (Stevens).

Meliola puiggarii Speg.
On *Rubus* sp., El Alto de la Bandera, Maricao (Stevens).

Meliola quadrispina Rac.
On *Ipomœa cathartica*, Las Marías (Stevens).

Meliola rectangularis Stevens.
On *Banisteria laurifolia*, Jayuya, Maricao, Utuado, Hormigueros, Mayagüez, Martín Peña (Stevens).
Coccoloba laurifolia, Arecibo-Lares (Stevens).

Meliola rudolphiæ Stevens.
On *Rudolphia volubilis*, Monte Alegrillo, Maricao, Luquillo Forest, El Alto de la Bandera, Aibonito (Stevens).

Meliola sepulta Pat.
On *Avicennia nitida*, Martín Peña.

Meliola serjaniæ Stevens.
On *Serjania polyphylla*, Vega Baja, Florida Adentro, Arecibo-Lares, Cataño (Stevens).

Meliola smilacis Stevens.
On *Smilax coriacea*, Manatí (Stevens).
Smilax sp., Algarrobo; Jájome Alto (Stevens).

Melola solani Stevens.
On *Solanum jamaicensis*, Monte de Oro (Stevens).

Meliola stenotaphri Stevens.
On *Paspalum plicatulum*, Río Piedras.
Stenotaphrum secundatum, Río Piedras; Manatí, Río Tanamá, Dos Bocas, Arecibo (Stevens).

Meliola tabernæmontanæ Speg.
On *Plumiera Krugii*, Maricao (Stevens).
Rauwolfia nitida, Martín Peña (Stevens).
Rauwolfia tetraphylla, Martín Peña.
Tabernæmontana oppositifolia, Mayagüez, Hormigueros (Stevens).

Meliola tabernæmontanæ var. forsteroniæ Stevens.
On *Forsteronia corymbosa*, Utuado (Stevens).

Meliola tecomæ Stevens.
On *Tecoma pentaphylla*, Río Piedras; Martín Peña, Mayagüez, Las Marías, Maricao (Stevens).
Tecoma sp., El Miradero, Las Marías, Mayagüez, Maricao, Quebradillas, Vega Baja, Arecibo-Lares (Stevens).

Meliola tenuissima Stevens.
On *Gouania lupuloides*, Camuy; Yauco, Villa Alba (Stevens).

Meliola thouiniæ Earle.
On *Allophylus crassinervis*, Quebradillas (Stevens).
Krugiodendron ferreum, Guayanilla, Río Tanamá, Quebradillas, Coamo (Stevens).
Thouinia striata, Vega Baja, Río Arecibo (Stevens) (21).
Winterana canella, Guayanilla, Mona Island (Stevens).

Meliola tortuosa Wint.
On *Piper medium*, Vega Baja (Stevens).
Piper peltatum, Río Piedras; Ponce (Heller); Mayagüez (W. & O.).
Piper umbellatum, Espinosa; Utuado, Indiera Fría, Mayagüez, Lares, Añasco, Monte Alegrillo, El Gigante, Jájome Alto, Dos Bocas, Las Marías, Río Tanamá, Maricao, Río Arecibo (Stevens) (21).

Meliola toruloidea Stevens.
On *Cassia quinquadrangulata*, Jájome Alto, Maricao, Aibonito (Stevens).
Inga laurina, Las Marías (Stevens); Maricao (W. & O.).
Inga vera, Mayagüez (W. & O.).

Meliola triloba Wint.
On *Pilea parietaria*, Arecibo-Lares, Dos Bocas, Río Arecibo (Stevens).

Meliola triumfettæ Stevens.
On *Hibiscus tiliaceus*, Arecibo-Lares, Maricao, Dos Bocas (Stevens).
Triumfetta semitriloba, Utuado, Indiera Fría (Stevens).
Triumfetta sp., Espinosa.

Meliola tuberculata Stevens.
On undet. host, Vega Baja (Stevens).

Myriosticta portoricensis Pat.
On *Vigna repens*. Coll. N. Y. Bot. Garden. Probably *Dimerium grammodes*.

Parodiella perisporioides (B. & C.) Speg.
See *Dimerium grammodes*.

PERISPORINA LANTANÆ Stevens.
On *Lantana camara*, Lares (Stevens) (82).

PERISPORIOPSIS WRIGHTII (B. & C.) Stevens.
On *Opuntia* sp., Mayagüez, Ponce (Stevens) (82).

PERISPORIUM BROMELIÆ Stevens.
On *Bromelia pinguin*, Río Piedras, Naguabo, Camuy; Mayagüez, Manatí, Utuado, Santa Ana, Cataño, Vega Baja, Florida Adentro, Lajas, Hormigueros, Coamo, Maricao, Añasco (Stevens) (82).

PERISPORIUM PORTORICENSIS Stevens.
On *Calophyllum calaba*, Mayagüez, Vega Baja (Stevens) (82).

PERISPORIUM TRUNCATUM Stevens.
On *Inga laurina*, Maricao, Mayagüez, El Alto de la Bandera, Coamo (Stevens).
Inga vera, Maricao (Stevens) (82).

PSEUDOMELIOLA (?) COLLAPSA Earle.
On *Meliola torulosa* en *Piper peltatum*.
Meliola sp., en *Hyptis capitatum* (21).

MICROTHYRIACEÆ.

ASTERINA CORIACELLA Speg. (?).
On *Cestrum laurifolium*. Coll. N. Y. Bot. Garden.

ASTERINA (ASTERELLA) FUMAGINA Dear. & Barth.
On *Lasiacis Sloanei* (*Panicum latifolium*) (?), Maricao (Stevens) (18). This is apparently the same as *Dimeriella olyra* Stevens.

ASTERINA SIDÆ Earle.
On *Sida carpinifolia*, Porto Rico (Heller) (21).

ASTERINA TRILOBA Earle.
On *Croton discolor*, Ponce (Heller) (21).

MICROPELTIS ÆRUGINESCENS Rehm.
On *Rourea glabra*, Río Piedras (W. & O.).

MICROPELTIS LAGUNCULARIÆ Wint.
On *Laguncularia racemosa*, Mayagüez (Heller) (19).

MICROPELTIS LONGISPORA Earle.
On *Coffea arabica*, Porto Rico (Heller) (21).

MICROPELTIS MANTHIÆ (?).
On *Adiantum latifolium*, Mayagüez (W. & O.).

MICROTHYRIUM URBANI Bres.
On *Shaefferia fructescens*, Cabo Rojo (Sintenis) (76).

NECTRIACEÆ

Borinquenia miconiæ Stevens.
On *Miconia lævigata*, Arecibo, Utuado (Stevens) (82).

Calonectria erubescens (Roberge) Sacc.
On dead leaves, Naranjito, Vega Baja, Aibonito (Fink).

Creonectria Bainii (Massee) Seaver.
On pods of *Theobroma cacao*, Mayagüez (Fawcett) (27).

Creonectria balansæ (Speg.) Seaver.
On dead wood, Río Piedras.

Creonectria grammicospora (Ferd. & Winge) Seaver.
On dead bark of *Cajanus indicus*, Río Piedras.

Creonectria ochroleuca (Schw.) Seaver.
(*Nectria ochroleuca* Schw.)
On dead bark, Santana (Stevens) (82).

Dexteria pulchella Stevens.
On *Paullinia pinnata*, Mayagüez (Stevens) (82).

Giberella pulicaris (Fries) Sacc.
On dead cane stalks, grass culms, Río Piedras, Carolina, Las Monjas, Guaynabo (48).

Hyalosphæra miconiæ Stevens.
On *Miconia lævigata*, Arecibo, Utuado, Maricao, Aguas Buenas, Ponce, Yabucoa (Stevens) (82).

Hyponectria phaseoli Stevens. In mss.
On *Vigna vexillata*, Porto Rico (Stevens).

Megalonectria pseudotrichia (Schw.) Speg.
On dead wood and bark, particularly of *Cajanus indicus*, Río Piedras, Pueblo Viejo, Moca (72, 90).

Nectria episphæria (Tode) Fries.
On dead wood, citrus twigs, and branches, often following *Corticium*, and on fruiting bodies of *Ustilina vulgaris*, Martín Peña, Bayamón, Río Piedras (89, 96).

Nectria flavociliata Seaver.
On dead wood and dead cane stalks, Río Piedras, Vega Baja (48).

Nectria laurentiana Marschal.
On dead and dying cane stalks, at times a wound parasite, Río Piedras, Carolina, Loíza, Las Monjas (48, 105).

NECTRIA RHYTIDOSPORA Pat.
On dead bark. Coll. N. Y. Bot. Garden.

NECTRIA SUFFULTA Berk. & Curt.
On stump of *Musa*, Río Piedras.

PLEONECTRIA MEGALONECTRIA Speg.
On dead and dying bark of *Cajanus indicus*, Espinosa.

SCOLECONECTRIA COCCICOLA (Ellis. & Ev.) Seaver.
(*Ophionectria coccicola* Ellis. & Ev.)
On various scale insects, on *Citrus* spp., particularly *Lepidosaphes beckii*. Río Piedras. Pueblo Viejo, Bayamón, Espinosa. Garrochales, Mayagüez (46, 96, 100).

SPHÆRODERMATELLA HELLERI (Earle) Seaver.
(*Melanospora* (?) *Helleri* Earle.)
On bark, Santurce (Heller) (19, 72, 73).

SPHÆROSTILBE COCCOPHILA (Desmaz.) Tul.
On various scale insects on *Citrus* spp., particularly *Lepidosaphes beckii*, Río Piedras, Pueblo Viejo, Bayamón, Vega Baja, Manatí, Espinosa, Garrochales, Mayagüez. Wide spread and always present in abundance (20, 46, 96, 100).

HYPOCREACEÆ.

BALANSIA HYPOXYLON (Peck) Atk.
(*Ephelis mexicana* Fries.)
(*Hypocrella hypoxylon* [Peck.] Sacc.)
On living stems of *Panicum tricanthum*, Río Piedras. Also reported from the Sintenis collection (76), on inflorescences of Gramineæ.

CHROMOCREA GELATINOSA (Tode) Seaver.
On dead cane stalks and debris, Río Piedras, Carolina (48).

CHROMOCREOPSIS STRIISPORA Stevenson.
On dead cane stalks, Gurabo (48).

CORDYCEPS BARBERI.
See *Isaria Barberi.*

CORDYCEPS DIPTERYGENA Berk. & Br.
On Drosophalid flies, particularly *Chrysomyia macellaria*, Río Piedras, Espinosa (94).

DOTHICHLŒ ARISTIDÆ Atkinson.
On *Aristida portoricensis*, Mayagüez (W. & O.). This fungus reported by Stevens (82) as *Balansia discoidea*.

DOTHICHLŒ ATRAMENTOSA (B. & C.) Atk.
On *Andropogon leucostachyus*, Las Marías (Stevens) (82).
Chloris petraea, Boquerón (W. & O.).

DOTHICHLŒ NIGRICANS (Speg.) Seaver.
(*Ephichlœ nigricans* Speg.)
On *Ichnanthus pallens*, Mayagüez, El Yunque (W. & O.). The same fungus reported by Stevens (82) as *Dothichloe aristidæ*.

GLAZIELLA AURANTIACA (Berk. & Curt.) Sacc.
On dead wood, Mameyes.

HYPOCREA RUFA (Pers.) Fries.
On dead cane trash and dead wood, Río Piedras, Naguabo (48).

HYPOCRELLA TAMONEÆ Earle.
On living leaves of *Tamonea* sp. Collections N. Y. Bot. Garden (73, 74).

PODOSTROMA BREVIPES (Mont.) Seaver.
On dead wood, El Yunque.

SPERMŒDIA STEVENSII Seaver.
(*Claviceps paspali* S. & H.)
On *Paspalum plicatulum*, Rosario, Ponce, Añasco, Cataño, Coamo, Mayagüez (Stevens) (82).

STILBOCREA HYPOCREOIDES (Kalchbr. & Cooke) Seaver.
On dead wood, Río Piedras, Espinosa, Bayamón.

USTILAGINOIDEA USAMBARENSIS P. Henn.
On *Panicum laxum*, Monte de Oro, El Alto de la Bandera (Stevens) (82).

DOTHIDIACEÆ.

AUERSWALDIA PALMICOLA Speg.
On *Acrista palmicola*, Adjuntas, El Gigante (Stevens) (38, 81).

MYRIOGENOSPORA BRESADOLEANA P. Henn.
On *Andropogon bicornis*, Río Piedras.
Axonopus compressus, *Mayagüez* (W. & O.).
Paspalum conjugatum, Sierra de Naguabo, Pueblo Viejo (81).

PHYLLACHORA ANDROPOGONIS (Schw.) Karst.[1]
On *Paspalum millegrana*, Naguabo (Stevens) (34).

[1] Dr. C. R. Orton in studying the Phyllachoras on grasses has indicated a number of new species from the Porto Rican collections, and in particular finds that specimens determined as *P. andropogonis* and *P. graminis* are not to be referred to these species. Since, however, his studies are not complete, the specimens in question have been listed as published.

PHYLLACHORA CASSIÆ P. Henn.
On *Cassia fistula,* Río Piedras, Quebradillas.

PHYLLACHORA CORNUOSPORA Atk.
On *Paspalum virgatum,* Río Piedras.

PHYLLACHORA CYPERI Rehm.
On *Cyperus giganteus,* Mayagüez (W. & O.)

PHYLLACHORA GALACTIÆ Earle.
On *Galactia striata,* Río Piedras, Espinosa, Camuy.
Galactia tenuiflora, Coamo Springs (Cooke & Collins).

PHYLLACHORA GRAMINIS (Pers.) Fuckel.[1]
On *Andropogon brevifolius,* Río Piedras.
Arthrostylidium sarmentosum, Utuado (Stevens) (82).
Lasiacis sorghoidea, Jájome Alto (Stevens).
Panicum sp., Maricao (Stevens).
Paspalum conjugatum, Vega Baja, El Alto de la Bandera (Stevens) (82).
Paspalum virgatum, Utuado (Stevens) (82).
Paspalum sp., Río Piedras; Sabana Grande (Stevens) (34).
Valota insularis, Quebradillas, Vega Baja, Santa Ana, Coamo (Stevens) (82).

PHYLLACHORA GRATISSIMA Rehm.
On *Persea americana,* Jayuya (Stevens) (60).

PHYLLACHORA INCLUSA (B. & C.) Sacc.
On *Jacquinia Berterii,* Ponce (Heller).

PHYLLACHORA LUTEO-MACULATA (Schw.) Orton.
On *Andropogon leucostachys,* Río Piedras.

PHYLLACHORA MAYDIS Maubl.
On *Zea mays,* Arecibo, Vega Baja, Río Piedras (16, 17, 18, 90). Given by Stevens and Dalby as *P. graminis.*

PHYLLACHORA MINUTA P. Henn.
On *Paritium tiliaceum,* Pueblo Viejo; Cataño (W. & O.).

PHYLLACHORA NITENS Garman.
On *Schlegelia brachyantha,* Maricao, Ponce, Monte Allegrillo, Río Grande, Preston's Ranch (Stevens) (34).

PHYLLACHORA PERFORANS (Rehm.) Sacc.
On *Securidaca virgata,* Río Piedras; Maricao, Rosario, Mayagüez (Stevens) (34, 82). Host reported erroneously by Garman as *Abrus precatorius.*

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[1] Dr. C. R. Orton in studying the Phyllachoras on grasses has indicated a number of new species from the Porto Rican collections, and in particular finds that specimens determined as *P. andropogonis* and *P. graminis* are not to be referred to these species. Since, however, his studies are not complete, the specimens in question have been listed as published.

PHYLLACHORA PERIBEBUYENSIS Speg.

On *Heterotrichum cymosum*, Jayuya (Stevens); El Yunque (W. & O.).

Miconia laevigata, Río Piedras, Maricao, Consumo Las Marías (Stevens).

Miconia Sintensii, Monte Alegrillo (Stevens).

Miconia sp., Río Piedras, Espinosa; Villa Alba, Maricao, Rosario (Stevens).

Tetrazygia elaeagnoides, Vega Baja, Espinosa; Barceloneta (W. & O.).

Tetrazygia sp., Santana (Stevens) (34).

PHYLLACHORA PUNCTA (Schw.) Orton.

On *Oplismenus hirtellus*, Espinosa.

PHYLLACHORA RENEALMIAE Rehm.

On *Alpinia antillarum*, Maricao, Monte Alegrillo, Utuado, Jájome Alto, El Yunque (Stevens) (34).

PHYLLACHORA SCLERIAE Rehm.

On *Scleria pterota*, Sierra de Naguabo, Espinosa, Río Piedras; Sabana Llana (Stevens) (82).

PHYLLACHORA SPHAEROSPERMA Winter.

On *Cenchrus echinatus*, Loíza, Campo Alegre; Vega Baja (Stevens) (34).

Cenchrus myosuroides, Mona Island (Stevens) (34).

SCIRRHIA LOPHODERMIOIDES Ellis & Ev.

On *Saccharum officinarum*, Río Piedras.

FIMETARIACEAE.

SPORORMIA MINIMA Auersw.

On cow manure, Río Piedras.

SPHAERIACEAE.

BERTIA MORIFORMIS (Tode) De Not.

On dead wood, El Yunque (Heller).

HERPOTRICHIA ALBIDOSTOMA (Peck) Sacc.

On rotten wood, Río Piedras.

HERPOTRICHIA DIFFUSA (Schw.) E. & E.

On coconut husks, Espinosa.

LASIOSPHAERIA PEZIZULA (B. & C). Sacc.

On dead bark, Dorado.

LIZONIA JACQUINIAE Bri. & Har.

On *Jacquinia barbasco* (*J. armillaris*) (Sintenis) (76).

MELANOMMA NITIDULUM Bres.

Reported from the Sintenis collection (76).

PHÆOSPORA CACTICOLA Stevens.

On *Rhipsalis cassytha*, Cayey (Stevens) (82).

ROSELLINIA AQUILA (Fr.) d. Not.

On dead wood, Río Piedras, Bayamón, Martín Peña.

ROSELLINIA BUNODES B. & Br.

On *Coffea arabica*, Mayagüez (Brandes) (31). Also reported by Fawcett (31) as attacking *Acalypha mosaica*, *Graptophyllum pictum*, *Jambosa jambos*, *Panax plumatum*, *Petiveria alliacea*, *Miconia* sp., *Piper* sp., and *Palicourea* sp.

ROSELLINIA PARAGUAYENSIS Stark.

On dead sugar-stalk, Río Piedras (48).

ROSELLINIA PULVERACEA (Ehrh.) Fuckel.

On dead sugar-cane stalks, Río Piedras.

ROSELLINIA SUBICULATA (Schw.) Sacc.

On dead wood, El Duque, Río Piedras, Martín Peña, Fajardo Garrochales.

ZIGNŒLLA ALGAPHILA Stevens. In mss.

On *Cephaleuros virescens* on *Artocarpus incisa*, Porto Rico (Stevens).

CUCURBITARIACEÆ.

NITSCHKIA NERVINCOLA Rehm.

On *Gesneria albiflora*, Maricao (Brittin); Mayagüez (Stevens) (82).

OTTHIA PANICI Stevens.

On *Panicum maximum*, Jayuya, Naguabo (Stevens) (82).

CORYNELIACEÆ.

CORYNELIA OREOPHILA (Speg.) Starb.

On *Podocarpus coriaceus*, Maricao (W. & O.). This species is reported by Dr. Stevens (82) as *Corynelia clavata* (S). Sacc. var. *portoricensis* Stevens.

CORYNELIA PTERIDICOLA Stevens.

On *Campyloncurum* sp., Añasco (Stevens) (82).

LOPHIOSTOMATACEÆ.

PLATYSOMIUM INDURATUM Earle.

Host not known. Coll. N. Y. Bot. Garden (Underwood and Griggs).

MYCOSPHÆRELLACEÆ.

GUIGNARDIA CEPHALARIÆ Aud. var. ALTERNANTHERÆ Sacc.
On *Alternanthera sessilis*, Río Piedras, Pueblo Viejo; Mayagüez, Las Marías, Utuado, Guayanilla (Stevens) (82).

GUIGNARDIA CLUSIÆ Stevens.
On *Clusia gundlachii*, Maricao (Stevens) (82).

GUIGNARDIA HELICTERES Stevens.
On *Helicteres jamaicensis*, Barceloneta (Stevens) (82).

GUIGNARDIA HETEROTRICHI Stevens.
On *Tetrotrichum cymosum*, Naguabo, Maricao, Villa Alba, Utuado (Stevens) (82).

GUIGNARDIA JUSTICIÆ Stevens. In mss.
On *Justicia verticillaris*, Porto Rico (Stevens).

GUIGNARDIA PIPERICOLA Stevens.
On *Piper marginatum*, Palo Seco; Lajas, Cabo Rojo (Stevens) (82).
Piper medium, Espinosa, Camuy; Vega Baja, Aguada, Trujillo Alto, St. Ana, Florida, Río Tanamá, Manatí, Peñuelas (Stevens) (82).

GUIGNARDIA PROMINENS Earle.
On *Aegiphila martinicense*, Santurce (Heller) (19).

GUIGNARDIA RYNCHOSPORÆ Stevens.
On *Rynchospora cyperoides* Martín Peña (Stevens) (82).

GUIGNARDIA TETRAZYGIA Stevens. In mss.
On *Tetrazygia* sp., Porto Rico (Stevens).

MYCOSPHÆRELLA AGGREGATA Schw.
On dead wood. Coll. N. Y. Bot. Garden.

MYCOSPHÆRELLA ANTHURII Miles.
On *Anthurium acaule*, Point Cangrejos; Aguas Buenas, Monte Alegrillo, Yabucoa, Trujillo Alto, Rosario, Cataño, Bayamón, Cabo Rojo, Las Bocas (Stevens) (61).

MYCOSPHÆRELLA CHRYSOBALANI Miles.
On *Chrysobalanus icaco*, Río Piedras (Stevens) (61).

MYCOSPHÆRELLA CITRULLINA (C. O. Sm.) Gros.
On *Cucumis melo*, Río Piedras (94).

MYCOSPHÆRELLA CLUSIÆ Stevens.
On *Clusia rosea*, Maricao, Lajas, Mayagüez, Utuado (Stevens) (82).

MYCOSPHÆRELLA DIDYMOPANACIS Miles.
On *Didymopanax morototoni*, Río Piedras, Bayamón; Añasco, Utuado (Stevens) (61).

MYCOSPHAERELLA DUBIA Miles.
On *Solanum* sp. (?), Maricao (Stevens) (61).

MYCOSPHÆRELLA FRAGARIÆ (Tul.) Lin.
On *Fragaria* sp., Río Piedras.

MYCOSPHÆRELLA GUTTIFERÆ Miles.
On *Clusia gundlachii*, Maricao (Stevens) (61).

MYCOSPHÆRELLA MACULIFORMIS (Pers.) Schw.
On *Inga vera*, Maricao (Stevens) (82).

MYCOSPHÆRELLA MAXIMA Miles.
On unknown host, Maricao (Stevens) (61).

MYCOSPHÆRELLA MAYDIS (Pass.)
On *Syntherisma sanguinale*, El Alto de la Bandera (Stevens) (82).

MYCOSPHÆRELLA MUCUNÆ Stevens.
On *Mucuna pruriens*, Añasco (Stevens) (82).

MYCOSPHÆRELLA PALMÆ Miles.
On leaves of palms, Guánica (Stevens) (61).

MYCOSPHARELLA PERSEÆ Miles.
On *Persea americana*, Pueblo Viejo, Río Piedras, Bayamón; Maricao, San Germán, Dos Bocas (Stevens) (60, 61).

MYCOSPHÆRELLA TABEBUIÆ Miles.
On *Tabebuia haemantha*, Vega Baja, Mona Island (Stevens) (61).

MYCOSPHÆRELLA TYROLENSIS Stevens. In mss.
On *Gymnogramma sulphurea*, Porto Rico (Stevens).

SPHÆRELLA SACCHARI Speg.
On dead leaves of sugar-cane, Fajardo, Río Piedras (48, 105).

PLEOSPORACEÆ.

LEPTOSPHÆRIA SACCHARI van Breda de H.
On *Saccharum officinarum*, Juncos, Río Piedras, Arecibo, Gurabo, Quebradillas (48, 82, 94, 105).

METASPHÆRIA ABORTIVA Stevens.
On *Varronia alba.*, Mayagüez, Maricao, Lares (Stevens) (82).

OPHIOBOLUS BARBATUS Pat. & Gaill.
On *Vitex* sp. (Stevens) (82).

PHYSALOSPORA ANDIRÆ Stevens.
On *Andira jamaicensis*, Sierra de Nagnabo, Río Piedras; Camuy, Mayagüez, Vega Baja, San Sebastián, Maricao, Cabo Rojo, Coamo, Quebradillas, Hormigueros, San Germán, Lajas, Martín Peña, Peñuelas, Lares, El Yunque (Stevens) (82).

PHYSALOSPORA BAMBUSÆ (Rab.) Sacc.
On *Lasiacis sorghoidea*, El Yunque (Stevens) (82).
PHYSALOSPORA CAROPHYLLINICOLA Stevens.
On *Drymaria cordata* Jayuya (Stevens) (82).
PHYSALOSPORA LAGUNCULARIÆ Rehm.
On *Laguncularia racemosa*, Guánica, Boquerón (Stevens) (82).
PHYSALOSPORA TUCUMANENSIS Speg.
On dead sugar-cane stalks, Carolina (48).

GNOMONIACEÆ.

ANTHOSTOMELLA RHIZOMORPHÆ Stevens. In mss.
On *Rhizophora mangle*, Martín Peña.
GLOMERELLA CINGULATA (Stonem.) S. & V. S.
(*Glomerella psidii* Dela.).
(*Glœosporium rufomaculans* [Berk.] Thüm.)
(*Glœosporium vanillæ* [Berk.] Cke.)
On *Citrus decumana*, (dead twigs), Río Piedras.
Psidium guajava, Mayagüez (Sheldon). Reported in Bull. 104, West Va. Agri. Exp. Station.
Vanilla planifolia, Mayagüez (Thomas).
LINOSPORA TRICHOSTIGMÆ Stevens. In mss.
On *Trichostigma octandra*, Porto Rico (Stevens).
TRABUTIA PORTORICENSIS Stevens. In mss.
On *Coccolobis nivea*, Porto Rico (Stevens).
TRABUTIELLA CORDIÆ Stevens. In mss.
On *Cordia collococca*, Porto Rico (Stevens).

VALSACEÆ.

VALSA SACCHARI Stevenson. (In ed.)
On dead sugar-cane stalks, Barceloneta.

MELANCONIDACEÆ.

MELANCONIS SACCHARI Mass.
On *Saccharum officinarum*, Mayagüez (Stevens) (82). Undoubtedly a mistake for *Melanconium sacchari* Mass.
VALSARIA SUBTROPICA Speg.
On dead cane-stalk, Río Piedras (82).

DIATRYPACEÆ.

DIATRYPE STIGMA (Hoffm.) Fr.
On dead wood, Martín Peña.

MELOGRAMMATACEÆ.

ENDOTHIA LONGIROSTRIS Earle.

On dead bark, Río Piedras, Sierra de Naguabo; Santurce (Heller) (82). Cultural and comparative studies reported by Shear *et al.*, in Bul. 380, U. S. Dept. of Agri.

ENDOTHIA PARRYI (Farl.) Cooke.

On *Agave rigida* var. *sissalana*, Maricao (Stevens) (82).

Furcræa tuberosa (*Fourcroya hexapetala*), Maricao, Monte Allegrillo, Trujillo Alto (Stevens) (82).

MYRMÆCIUM CANNÆ Dearn. & Barth.

On *Canna indica*, Cabo Rojo (Stevens) (18).

MYRMÆCIUM RUBICOSUM (Tul.) Nits.

On dead bark, Naguabo.

XYLARIACEÆ.

DALDINIA CONCENTRICA (Bolt.) E. & E.

On dead wood, Garrochales, Palo Seco, Pueblo Viejo, Martín Peña, Espinosa (96). Reported from Humacao (Schwanecke) (50) as *Sphæria concentrica* Bolt.

HYPOXYLON ANNULATUM Mont.

On dead wood, Palo Seco.

HYPOXYLON FUSCOPURPUREA Berk.

On dead citrus branches, Campo Alegre, Bayamón (96).

HYPOXYLON PERFORATUM (Schw.) Fr.

On dead bamboo, Río Piedras.

HYPOXYLON RUBIGINOSUM Fr.

On dead wood, Río Piedras, Martín Peña.

KRETZSCHMARIA CENOPUS (Mont.) Karsten.

On dead wood, El Duque, Aibonito, Río Piedras.

KRETZSCHMARIA RUGOSA Earle.

On dead wood, Sierra de Naguabo, El Yunque.

NUMMULARIA BULLIARDII Tul.

On dead wood, or occasionally as a wound parasite of *Ficus nitida* and other trees, Río Piedras, Sierra de Naguabo, Martín Peña, El Yunque, Comerío (89).

NUMMULARIA GLYCYRRHIZA B. & C.

On dead wood. Reported from the Sintenis collection (76). Probably is *N. Bulliardii.*

NUMMULARIA REPANDA Nitsch.

On dead wood, El Yunque.

PORONIA ŒDIPUS Mont.

On manure, Río Piedras. Cortada.

USTILINA VULGARIS Tul.

On dead wood and on the larger roots and crowns of dying grapefruit trees (*Citrus decumana*). Río Piedras, Martín Peña, Palo Seco (89, 96). What is probably the same species is reported from the Schwanecke collection (50) as *Hypoxylon vulgare* Link.

XYLARIA APICULATA Cooke.

(*Xylaria arbuscula* Sacc.)

On dead wood. Río Piedras. Martín Peña. Espinosa. Bayamón (48, 54).

XYLARIA ARISTATA Mont.

On dead wood. Río Piedras.

XYLARIA AXIFERA Mont.

On dead wood. Río Piedras. El Yunque.

XYLARIA BERKELEYI Mont.

On dead wood. Sierra de Naguabo. El Yunque.

XYLARIA CLAVICULARIS Klotzsch.

On rotten wood. Naguabo. Reported from the Schwanecke collection (50), but nothing more is known about it.

XYLARIA CUBENSIS Mont.

On dead wood. Mameyes. Sierra de Naguabo. *Xylaria involuta* of the Sintenis collection (76) is referred (Lloyd) to this species.

XYLARIA EUGLOSSA Fries.

On dead wood. Río Piedras.

XYLARIA FIMBRIATA Lloyd.

On dead wood and soil. Río Piedras. Bayamón (55).

XYLARIA MULTIPLEX Fr.

On old pods of *Hymenaea courbaril*. Río Piedras.

XYLARIA OBOVATA Berk.

On dead wood, El Yunque.

XYLARIA OBTUSSISSIMA Berk.

Reported from the Sintenis collection (76).

XYLARIA PARTITA Lloyd.

On dead wood, Río Piedras (54).

XYLARIA POLYMORPHA (Pers.) Grev. (?).

On dead wood. Mayagüez (Stevens) (82).

XYLARIA PORTORICENSE Klotzsch.

Reported from both the Schwanecke and Sintenis collections (in the latter as forma *minor*), but nothing further is known about the species (50, 76).

XYLARIA SCHWEINITZII Berk.

On dead wood, Aibonito, Río Piedras.

XYLARIA SCOPIFORMIS Mont.

On dead wood, Río Piedras, Martín Peña; Utuado (Sintenis) (76). A specimen from Cabo Rojo reported by Stevens (82) as *X. hypoxylon* (L.) Grev. belongs here (54).

HYSTERIACEÆ.

LEMBOSIA AGAVES Earle.

On *Agave* sp., Cabo Rojo (Heller) (18).

LEMBOSIA COCCOLOBÆ Earle.

On *Coccoloba uvifera*, Cangrejos. First reported from the Heller collection (21).

LEMBOSIA DIFFUSA Wint.

On *Miconia* sp. Coll. N. Y. Bot. Garden (Heller).

TRIBLIDIUM RUFULUM Spreng.

On dead sticks, Martín Peña, Pueblo Viejo, Río Piedras, Espinosa, Garrochales, Carolina, Bayamón, Campo Alegre, El Duque (96).

PEZIZACEÆ.

COOKEINA SULCIPES (Berk.) O. Kuntze.

On dead and rotten wood, Río Piedras, Mameyes.

COOKEINA TETRASPORA Seaver.

On palm leaves, El Yunque.

COOKEINA TRICHOLOMA (Mont.) O. Kuntze.

On dead wood, Río Piedras.

LACHNEA CUBENSIS (B. & C.) Sacc.

On dead sugar-cane stalks and debris, Río Piedras (48).

PHILLIPSIA DOMINGENSIS Berk.

On dead wood, Río Piedras, Mameyes, Martín Peña.

ASCOBOLACEÆ.

ASCOBOLUS MAGNIFICUS Dodge.

On cow manure, Río Piedras.

ASCOBOLUS STERCORARIUS (Bull). Rehm.

Fimicole. Col. N. Y. Bot. Garden.

ASCODESMIS PORCINA Seaver.
Fimicole, Mayagüez (Fawcett) (75).

ASCOPHANUS CARNEUS (P.) Boud.
On debris. Coll. N. Y. Bot. Garden.

ASCOPHANUS GRANULATUS (Bull.) Speg.
On debris, Aibonito. Mayagüez, El Yunque (Fink)

ASCOPHANUS TESTACEUS (Moug.) Phil.
On rotting leather. Bayamón.

SACCOLOBUS KERVERNI (Crew.) Boud.
Coll. N. Y. Bot. Garden.

SACCOLOBUS PORTORICENSIS Seaver.
Coll. N. Y. Bot. Garden.

HELOTIACEÆ.

HELOTIUM CITRINUM (Hedw.) Fr.
On dead wood. Coll. N. Y. Bot. Garden

MOLLISIACEÆ.

TRICHOBELONIUM ALBOSUCCINEUM Rehm.
On dead leaves. Coll. N. Y. Bot. Garden.

PATELLARIACEÆ.

KARSCHIA LIGNYOTA (Fr.) Sacc.
On dead wood, Manatí (Fink).

LECANIDION CYANEUM (Cooke) Sacc.
On dead citrus twigs, Campo Alegre (96).

DERMATEACEÆ.

MIDOTIS HETEROMERA Mont.
On wood, Mt. Cienege (Sintenis) (76).

ORBILIA CHRYSOCOMA (Bull.) Sacc.
On dead wood. Coll. N. Y. Bot. Garden.

STICTIDACEÆ.

STICTIS FOLICOLA B. & C.
On dead leaves, Río Piedras.

STICTIS RADIATA Pers.
On dead citrus twigs, Campo Alegre, Sabana Llana. Espinosa, Río Piedras (96).

BASIDIOMYCETES.

USTILAGINACEÆ.

CINTRACTIA AXICOLA (Berk.) Cornu.
On *Fimbristylis* sp., Quebradillas, Bayamón, Mayagüez (Stevens) (82).
Fimbristylis diphylla, Dorado, Río Piedras; El Yunque, San Juan, Quebradillas, Lares (Stevens) (82).
Fimbristylis ferruginea, Santurce (Stevens) (4).

CINTRACTIA AXICOLA MINOR Clinton.
On *Cyperus sphacelatus*, Campo Alegre, Naguabo; Río Piedras (W. & O.) (14).

CINTRACTIA LEUCODERMA (Berk.) P. Henn.
(*Cintractia Krugiana* P. Magnus) (76).
On *Rynchospora* sp., Río Piedras, Pueblo Viejo, Bayamón; Cataño, El Yunque, Manatí (Stevens) (82).
Rynchospora gigantea, Martín Peña; Manatí (Sintenis).
Rynchospora corymbosa, Pueblo Viejo, Mayagüez, Cataño (Stevens) (14, 76, 82).

CINTRACTIA LIMITATA Clinton.
On *Cyperus ligularis*, Mayagüez, San Juan (Clinton); Boquerón (Stevens) (14, 82).

CINTRACTIA UTRICULICOLA (P. Henn.) Clinton.
On *Rynchospora aurea*, Mayagüez (Stevens) (82).
Rynchospora corymbosa, Río Piedras; Mayagüez (Stevens) (14, 82).

MYKOSYRINX CISSI (D. C.) G. Beck.
(*Schrœteria cissi* D. C.) (76).
On *Cissus acida*, Salinas, Cabo Rojo (Sintenis).
Cissus erosa, Maricao (Sintenis).
Cissus sicyoides (14).

SPHACELOTHECA PANICI-LEUCOPHÆI (Bref.) Clinton.
On *Valota insularis* (*Trichachne insularis*), Campo Alegre; Barceloneta, Boquerón (W. & O.); Coamo Springs (Stevens) (14, 82).

SPHACELOTHECA PASPALI-NOTATI (P. Henn) Clinton.
On *Paspalum* sp., Río Piedras.

TOLYPOSPORELLA BRUNKII (E. & G.) Clinton.
On *Andropogon Bicornis*, El Yunque (W. & O.).

USTILAGO SEGETUM Dittm.
Reported from the Schwanecke Collection (50). Host not given.

USTILAGO AFFINIS E. & E.

On *Stenotaphrum secundatum*, Río Piedras, Campo Alegre, Cayey; Barceloneta (W. & O.); Arecibo, Bayamón, Punta Santiago (Stevens) (82).

USTILAGO ZEÆ (Beckm.) Unger.

On *Zea mays*, Garrochales, Río Piedras; San Germán (Stevens) (14, 82, 90, 94).

TILLETIACEÆ.

BURRILLIA ECHINODORI Clinton.

On *Echinodorus cordifolius*, Palo Seco; Guánica (Stevens) (82).

DOASSANSIA SINTENISII Bres.

Reported from the Sintenis collection (76), but said by Clinton (14) to be insect work only.

ENTYLOMA AUSTRALE Speg.

On *Physalis* sp. (14).

ENTYLOMA GUARANITICUM Speg.

On *Bidens leucantha*, Río Piedras, Palo Seco, Bayamón (14).

ENTYLOMA LOBELIÆ Farl.

On *Lobelia* sp. (14).

THECAPHORA PUSTULATA Clinton (n. sp.).

On *Bidens leucantha*, Camuy; Mayagüez (W. & O.).

UROCYSTIS CEPULÆ Frost.

On *Allium sepa*. Mentioned by Henricksen (36, 90). Occurrence in Porto Rico doubtful.

UREDINALES.[1]

COLEOSPORIACEÆ.

COLEOSPORIUM ELEPHANTOPODIS (Schw.) Thüm.

On *Elephantopus mollis*, Espinosa, Río Piedras, Naguabo; Maricao, Corozal, Yauco, Jájome Alto, Jayuya, Mayagüez, Dos Bocas, Santana (Stevens); Bayamón (Holway); Mayagüez (Heller) (1, 19).

COLEOSPORIUM EUPATORII Arthur.

On *Eupatorium macrophyllum*, Garrochales. First report from Porto Rico.

[1] The *Uredinales* of Porto Rico have been very completely dealt with by Dr. Arthur in his publications in Mycologia (3, 4), based on the collections of Dr. F. L. Stevens and those of Prof. H. H. Whetzel and Dr. E. W. Olive. The list given here is based upon these papers, with the addition of the localities of our collections and three previously unreported species. Citations to the papers by Dr. Arthur are omitted since practically all species are there included.

COLEOSPORIUM IPOMŒÆ (Schw.) Burr.

On *Ipomæa angustifolia*, Campo Alegre.

Ipomæa batatas, Río Piedras: Naguabo (Stevens): Barceloneta, El Yunque (W. & O.)[2] (6, 81, 90, 94).

Ipomæa littoralis, San Juan (Holway).

Ipomæa nil, Guayanilla (Stevens).

Ipomæa rubra, Río Piedras: El Yunque (W. & O.).

Ipomæa stolonifera, Santurce; Vieques (Shafer) (102).

Jacquemontia tamnifolia, Río Piedras: Añasco (W. & O.).

Quamoclit coccinea, Vieques (Shafer).

COLEOSPORIUM PLUMIERÆ Pat.

On *Plumiera alba*, Guánica (W. & O.).

Plumiera Krugii, Maricao, Monte Alegrillo (Stevens).

Plumiera obtusa, Mona Island (Stevens) (12).

UREDINACEÆ.

CEROTELIUM CANAVALLE Arth.

On *Canavali* sp., Río Piedras, Garrochales, Espinosa, Campo Alegre (1, 94).

Canavali ensiformis, Mayagüez (Clinton); Manatí (Stevens); Barceloneta (W. & O.).

Canavali gladiata, Mayagüez (Thomas); Río Piedras (Stevens) (82).

KUEHNEOLA FICI (Cast.) But.

On *Carica papaya*, reported from the Whetzel and Olive collection, but an error. The fungus on this host is *Pucciniopsis carica* Earle.

Ficus carica, Naguabo; San Juan (Earle) (1, 81, 94).

Ficus crassinervia, El Yunque (W. & O.).

Ficus lævigata, Santurce, Vega Baja, Mona Island, Cabo Rojo, Dos Bocas (Stevens); Barceloneta (W. & O.).

Ficus lentiginosa, Mayagüez, Yauco (W. & O.).

Ficus sp., Jayuya (Stevens).

KUEHNEOLA GOSSYPII (Lagerh.) Arth.

On *Gossypium barbadense*, Garrochales, Trujillo Alto; Isabela, Mona Island (Stevens) (12, 20, 81).

Gossypium brasiliense, Dos Bocas (Stevens).

Gossypium hirsutum, Mayagüez (Earle); Añasco, Yauco, Barceloneta (W. & O.) (1).

Gossypium sp., Río Piedras, (W. & O.).

[2] Whetzell and Olive.

KUEHNEOLA MALVICOLA (Speg.) Arth.
On *Malache scabra*, Martín Peña (W. & O.).

MILESIA COLUMBIENSIS (Dietel) Arth.
On *Nephrolepis rivularis*, Aguealtaria (Stevens).

OLIVEA CAPITULIFORMIS (P. Henn.) Arth.
(*Uredo capituliformis* P. Henn.)
On *Alchornea latifolia*, Naguabo: El Yunque (W. & O.); Preston's Ranch, Luquillo (Stevens).

OLIVEA PETITIÆ Arth.
On *Petitia domingensis*, Maricao (W. & O.).

PHYSOPELLA CONCORS Arthur.
(*Uredo concors* Arthur.)
On *Dolichos lablab*, Bayamón; El Yunque (W. & O.); Jayuya (Stevens).
Phaseolus lunatus, Bayamón, Mayagüez (94).
Teramnus uncinatus, Jayuya (Stevens).

PHYSOPELLA MEIBOMIÆ Arth.
On *Meibomia supina*, Añasco, Río Tanamá (W. & O.).

PHYSOPELLA VITIS (Thüm) Arth.
On *Vitis vinifera*, Pastillo Springs, Mayagüez (Stevens); Maricao (W. & O.) (81).

SCHRŒTERIASTER FENESTRALA Arth.
(*Uredo fenestrala* Arth.)
On *Phyllanthus distichus*, Sabana Llana; Mayagüez, Guánica (W. & O.).
Phyllanthus grandifolius, Bayamón, Villa Alba, Martín Peña (Stevens).
Phyllanthus niruri, Río Piedras.

ÆCIDIACEÆ (PUCCINIACEÆ).

ARGOMYCES INSULANUS Arth.
On *Vernonia albicaulis*, Dos Bocas (Stevens).
Vernonia longifolia, Villa Alba (Stevens).

ARGOMYCES VERNONIÆ Arth.
On *Vernonia albicaulis*, Bandera (Stevens).
Vernonia borinquensis, Consumo, Jájome Alto, El Gigante (Stevens); Cayey (Holway); Maricao (W. & O.) (1).
Vernonia phyllostachya, Cabo Rojo (Stevens); Barceloneta (W. & O.).

BOTRYORHIZA HIPPOCRATEA W. & O.

On *Hippocratea volubilis*, Río Piedras, Espinosa, Campo Alegre; Mayagüez, Barceloneta, El Yunque (W. & O.); Ciales, Rosario, Maricao, Vega Baja, San Germán, Luquillo, Joyuda (Stevens) (71, 82).

ENDOPHYLLUM CIRCUMSCRIPTUM (Schw.) W. & O.

(*Aecidium circumscriptum* Schw.)

On *Cissus sicyoides*, Río Piedras, Comerío, Pueblo Viejo, Camuy, Guaynabo; Mayagüez, San Germán, Luquillo, Corozal, Manatí, Aguada, Aguadilla, Jájome Alto Guayanilla, Jayuya, El Gigante, Cabo Rojo, Dos Bocas, Naguabo (Stevens); Maricao, Río Tanamá, Coamo (W. & O.) (71).

ENDOPHYLLUM DECOLORATUM (Schw.) W. & O.

(*Aecidium decoloratum* Schw.)

On *Clibadium erosum*, Jájome Alto (Stevens); El Yunque (W. & O.) (71).

ENDOPHYLLUM STACHYTARPHETÆ (Henn.) W. & O.

On *Valerianodes cayennensis*, Espinosa, Río Piedras (71).

ENDOPHYLLUM WEDELLE (Earle) W. & O.

(*Aecidium wedeliæ* Earle.)

On *Wedelia trilobata*, Cataño, Trujillo Alto, Río Piedras, Campo Alegre; Mayagüez, Cabo Rojo, Utuado, Maricao, Santana, El Gigante (Stevens); Barceloneta (W. & O.) (19, 71).

ENDOPHYLLOIDES PORTORICENSIS W. & O.

(*Aecidium expansum* Diet.)

On *Mikania cordifolia*, Naguabo; Coamo Springs, Mayagüez, Yauco, Monte de Oro, Lares, Jájome Alto, Dos Bocas, Villa Alba (Stevens); Maricao, San Germán, El Duque (W. & O.).

Mikania odoratissima, El Yunque, El Duque (W. & O.) (71).

HEMILEIA VASTATRIX Berk. & Br.

Said to have been introduced once on *Coffea arabica* (1, 81), but eradicated.

PROSPODIUM APPENDICULATUM (Wint.) Arth.

On *Stenolobium stans*, Hormigueros (Stevens); Santurce (W. & O.).

PROSPODIUM PLAGIOPUS (Mont.) Arth.

On *Tecoma pentaphylla*, Añasco, Río Piedras (W. & O.).

Puccinia angustatoides Stone.

On *Rynchospora aurea*, Mayagüez (Clinton).

Rynchospora corymbosa, Pueblo Viejo; Mayagüez (W. & O.).

Rynchospora cyperoides, El Yunque, Cataño (W. & O.).

Puccinia arechavelatae Speg.

On *Cardiospermum halicacabum*, Guánica (Sintenis) (76).

Cardiospermum microcarpum, Santana, Bayamón; Quebradillas, Desecheo (Stevens); San Juan (Holway); Fajardo, Maricao (W. & O.).

Puccinia blechi Lagerh.

On *Blechum Brownei*, Río Piedras, Sierra de Naguabo; Mayagüez (Stevens).

Puccinia cameliae (Mayor) Arthur.

On *Chaetochloa setosa*, Mona Island (Stevens) (12).

Puccinia canaliculata (Schw.) Lagerh.

On *Cyperus articulatus*, Naguabo.

Cyperus cayennensis, Mayagüez (Clinton).

Cyperus distans, Porto Rico (Stevens).

Cyperus ferax, Río Piedras; Naguabo (Olive).

Cyperus giganteus, Mayagüez (W. & O.).

Cyperus laevigatus, Guánica (Stevens); Mayagüez (W. & O.).

Cyperus odoratus, San José, Río Piedras (Stevens); Martín Peña, Naguabo (W. & O.).

Cyperus polystachus, Cataño (Heller).

Cyperus radiatus, Canóvanas, Pueblo Viejo; Mayagüez (Stevens); Naguabo (W. & O.).

Cyperus reticulatus, Naguabo (W. & O.).

Cyperus spathcelatus, Espinosa, Sabana Llana, Río Piedras, Mayagüez, La Carmelita (Clinton); Campo Alegre, Cataño (W. & O.).

Cyperus surinamensis, Bayamón, Martín Peña; Añasco (Heller); Naguabo (Olive).

Cyperus sp., Villa Alba (Stevens).

Kyllingia brevifolia, Martín Peña (W. & O.).

Kyllingia pumila, Pueblo Viejo, Río Piedras; Añasco, El Yunque (W. & O.).

Puccinia cannae (Wint.) P. Henn.

On *Calathea lutea*, Mayagüez (Stevens) (81).

Canna coccinea, Mameyes (Stevens); Maricao (W. & O.).

Canna glauca, Cabo Rojo (Stevens).

PUCCINIA CANNÆ (Wint.) P. Henn.—*Continued.*

On *Canna* sp., Espinosa, Naguabo, Campo Alegre, Río Piedras, Santurce, Corozal, Mayagüez, Añasco, Rosario (Stevens); Barceloneta (W. & O.).

Thalia geniculata, Añasco, Mayagüez (Stevens).

PUCCINIA CENCHRI Diet. & Holw.

On *Cenchrus carolinianus*, Camuy (Stevens).

Cenchrus echinatus, Guánica, Mona Island (Stevens); Mayagüez, Boquerón, Yauco, San Germán, Barceloneta, Río Tanamá (W. & O.) (12).

Cenchrus viridis, Campo Alegre; Guánica, Mona Island, Guayama (Stevens).

PUCCINIA CLADII Ell. & Tracy.

On *Mariscus jamaicensis*, Martín Peña (W. & O.).

PUCCINIA CONCRESCENS E. & E.

On *Asclepias curassavica*, Espinosa, Ciales; Vega Baja, Aibonito, Manatí, Jájome Alto (Stevens); Comerío (Holway); Maricao (W. & O.) (1).

Asclepias nivea, Maricao (W. & O.).

PUCCINIA CORDIÆ Arth.

On *Cordia alliodora*, Ponce (Holway).

PUCCINIA CRASSIPES Berk. & Curt.

On *Ipomaea triloba*, Cortada, Mona Island (Stevens) (12).

PUCCINIA CUTICULOSA (Ell. & Ev.) Arth.

On *Cydista aequinoctialis*, Martín Peña (W. & O.).

PUCCINIA CYNODONTIS De Lac.

On *Capriola dactylon*, Río Piedras; Mayagüez (Stevens); Naguabo (W. & O.).

PUCCINIA DEFORMATA Berk. & Curt.

On *Olyra latifolia*, San Germán (Stevens).

PUCCINIA ELEOCHARIDIS Arth.

On *Eleocharis capitata*, Martín Peña; Laguna San José (Stevens); Mayagüez (W. & O.).

Eleocharis cellulosa, Santurce (Stevens).

Eleocharis flaccida, Bandera (Stevens).

Eleocharis geniculata, Naguabo; Mayagüez (Stevens); Añasco (Heller) (19).

Eleocharis interstincta, Mayagüez (Stevens).

Eleocharis mutata, Guanajibo (Stevens); Martín Peña (W. & O.).

PUCCINIA ELEOCHARIDIS Arth.—*Continued.*

On *Eleocharis* sp., Cataño (Stevens): Mayagüez (Heller, Clinton).

PUCCINIA EUPHORBIÆ P. Henn.

On *Aklema petiolaris*, Mona Island (Stevens) (12).

PUCCINIA FALLACIOSA Arth.

(*Uredo fallaciosa* Arthur.)

On *Palicourea crocea*, Mayagüez, Maricao (W. & O.).

Palicourea riparia, El Yunque (W. & O.).

Psychotria patens, Maricao, Ponce (Stevens).

PUCCINIA FARINACEA Long.

On *Salvia coccinea*, El Gigante (Stevens): Mayagüez, Maricao (W. & O.).

PUCCINIA FIMBRISTYLIDIS Arth.

On *Fimbristylis diphylla*, Río Piedras: Ponce (Stevens); Barceloneta, Campo Alegre (W. & O.).

Fimbristylis ferruginea, Martín Peña: Joynda, Santurce (Stevens).

Fimbristylis miliacea, Río Piedras.

Fimbristylis sp., Mayagüez (Clinton).

PUCCINIA GOUANIÆ Holw.

On *Gouania lupuloides*, Rosario, Yauco, Cabo Rojo (Stevens); Mayagüez (Holway).

Gouania polygama, Mayagüez, Rosario, Lares, Aguadilla, San Germán (Stevens); Añasco (W. & O.).

PUCCINIA HELICONIÆ (Deit.) Arth.

(*Uredo heliconiæ* Diet.)

On *Bihai borinquena*, El Yunque (W. & O.). The new combination made by Dr. Arthur in Bul. Tor. Bot. Club, v. 75, no. 4, April 1918, pp. 144–5.

PUCCINIA HETEROSPORA B. & C.

(*Uromyces paronia* Arth.)

On *Abutilon hirtum*, Guánica (Stevens).

Abutilon indicum, Peñuelas, Tallaboa, Coamo (Sintenis) (76).

Malache scabra, Mayagüez, Jayuya (Underwood).

Sida cordifolia, Cabo Rojo (Sintenis) (76).

Sida glutinosa, Villa Alba (Stevens).

Sida hederifolia, Mayagüez (W. & O.).

Sida humilis, Martín Peña: Boquerón (Stevens): Vieques (Shafer): Yauco (W. & O.): Guánica (Sintenis) (76).

PUCCINIA HETEROSPORA B. & C.—*Continued.*
On *Sida procumbens*, Guánica, Desecheo (Stevens).
Sida spinosa, Guayama (Stevens).
Sida urens, Garrochales, Río Piedras; Guayanilla, Coamo Springs, Vega Baja, Yauco, Maricao, Rosario, Vega Alta, Ponce, Aguada, El Gigante, Mayagüez (Stevens): Añasco, Boquerón (W. & O.).
Wissadula periplocifolia, Coamo Springs, Guánica (Stevens).

PUCCINIA HUBERI P. Henn.
On *Panicum fasciculatum*, Vega Baja; Río Tanamá (Stevens); Barceloneta (W. & O.).
Panicum trichoides, Aibonito, Río Piedras; Villa Alba, Maricao, Adjuntas, Jayuya (Stevens); La Carmelita (Clinton); Mayagüez, Río Tanamá (W. & O.).
Panicum utowanaum, Mona Island (82).

PUCCINIA HYDROCOTYLES (Link.) Cook.
On *Hydrocotyle australis*, Pueblo Viejo.
Hydrocotyle umbellata, Mayagüez, Yauco (W. & O.).

PUCCINIA HYPTIDIS (M. A. Curt.) Tracy & Earle.
On *Hyptis capitata*, Río Piedras, Mayagüez; Bayamón (Holway); Maricao (W. & O.); Villa Alba, Coamo Springs, Vega Baja, Añasco, Rosario, Quebradillas, Monte de Oro, Lares, El Gigante (Stevens).

PUCCINIA INFLATA Arth.
On *Stigmaphyllon lingulatum*, Santurce, Mayagüez; Ponce (Holway); Desecheo, Boquerón, Guánica, Coamo Springs, Mona Island (Stevens); Yauco, Fajardo, Coamo (W. & O.) (12).

PUCCINIA INSITITIA Arth.
On *Hyptis lantanifolium*, Aibonito (Stevens); Maricao (W. & O.).

PUCCINIA LANTANÆ Farl.
On *Lantana camara*, Guánica, Lares, Guayanilla (Stevens).
Lantana involucrata, Quebradillas; Boquerón, Arecibo, Quebradillas, San Germán, Mona Island (Stevens); Yauco (W. & O.).

PUCCINIA LATERITIA Berk. & Curt.
On *Borreria laevis*, Río Piedras, Canóvanas; Mayagüez (Clinton); Vega Baja, Cabo Rojo, Coamo Springs, San Sebastián (Stevens).

PUCCINIA LATERITIA Berk & Curt.—*Continued.*

On *Borreria verticillata*, Río Piedras; Mayagüez, Boquerón, Bayamón, Indiera Fría, Cataño, Utuado, Lares, Aguada, Quebradillas (Stevens); Maricao, San Germán, Barceloneta (W. & O.).

Diodia littoralis, Boquerón (W. & O.).

Diodia maritima, Palo Seco, Cataño; Mayagüez (Stevens), Santurce (W. & O.).

Diodia rigida, Campo Alegre, Espinosa, Garrochales, Camuy, Naguabo; Manatí, Río Piedras (Stevens); Mayagüez, Barceloneta (W. & O.).

Ernodea littoralis, Boquerón, Mona Island (Stevens) (12).

Mitracarpus portoricensis, Guánica (Stevens).

Spermacoce riparia, Aguadilla (Stevens).

Spermacoce tenuior, Campo Alegre; Hormigueros, Guánica, Coamo Springs, Cabo Rojo, San Germán (Stevens); Vieques (Shafer) (102).

PUCCINIA LEONOTIDIS (P. Henn.) Arthur.

On *Leonotis nepetaefolia*, Río Piedras, Espinosa; Yabucoa, Coamo Springs, Hormigueros, Bayamón, Lares, Guayama, Guayanilla (Stevens); Ponce (Holway); Mayagüez, Yauco, Boquerón, Barceloneta (W. & O.).

PUCCINIA LEVIS (Sacc. & Bizz.) Mag.

On *Paspalum fimbriatum*, Cabo Rojo (Stevens); Yauco (W. & O.).

Paspalum millegrana, Campo Alegre (W. & O.).

Paspalum plicatulum, Río Piedras; Vega Baja (Stevens).

Rytilix granularis, Rosario (Stevens); Maricao (Sintenis) (76).

PUCCINIA LITHOSPERMI Ell. & Kellerm.

On *Evolvulus nummularius*, Mayagüez, Añasco (W. & O.).

PUCCINIA MACROPODA Speg.

On *Iresine elatior*, Desecheo (Stevens).

PUCCINIA MEDELLINENSIS Mayor.

On *Hyptis atrorubens*, Río Piedras, Espinosa; Santurce (Stevens); Martín Peña, Naguabo (W. & O.).

Hyptis pectinatum, Río Piedras; Villa Alba, Coamo Springs, Corozal, Mayagüez, Rosario, Lares, Cabo Rojo (Stevens); Maricao, Yauco (W. & O.) (1).

PUCCINIA MEDELLINENSIS Mayor.—*Continued.*

On *Hyptis suaveolens*, Vega Baja; Mayagüez, Ponce, Aguada, Guayama, Guayanilla (Stevens); La Carmelita (Clinton); Aibonito (Holway); Añasco (W. & O.).

PUCCINIA OBLIQUA Berk. & Curt.

On *Melastelma lineare*, Espinosa; Barros (Stevens); Maricao (W. & O.).

Melastelma parviflorum, Vega Baja, Quebradillas (Stevens); Mayagüez (W. & O.).

PUCCINIA ORMOSIAE Arth.

On *Ormosia Krugii*, Sierra de Naguabo; El Yunque (W. & O.).

PUCCINIA POLYGONI-AMPHIBII Pers.

On *Persicaria portoricensis*, Río Piedras.

Persicaria punctata, Sabana Llana; Mayagüez, Coamo (W. & O.).

PUCCINIA PSIDII Wint.

On *Jambos jambos*, Consumo, Maricao, Río Piedras, Barros, Villa Alba, Monte de Oro, Jájome Alto, El Gigante (Stevens).

Psidium guayava, Villa Alba (Stevens).

PUCCINIA PURPUREA Cooke.

On *Holcus halepensis*, Palo Seco, Sabana Llana, Vega Baja.

Holcus sorghum, Patillas, Mayagüez, Río Piedras, Ensenada, Trujillo Alto; La Carmelita (Clinton) (94).

Holcus sorghum var. *sudanensis*, Río Piedras, Trujillo Alto; Mayagüez (W. & O.) (94).

PUCCINIA RIVINAE (Berk. & Curt.) Speg.

On *Rivina humilis*, Desecheo (Stevens); Yauco (W. & O.); Fajardo (Sintenis) (76).

Trichostigma octandrum, Yauco, Coamo (W. & O.).

PUCCINIA ROSEA (Diet. & Holw.) Arth.

On *Ageratum conyzoides*, Villa Alba, Utuado, Monte Allegrillo (Stevens); Yauco (W. & O.).

Eupatorium polyodon, Barros (Stevens).

PUCCINIA SALVIICOLA Diet. & Holw.

On *Salvia occidentalis*, Camuy, Palo Seco; Mayagüez, Corozal, Aguada (Stevens); Caguas (Heller); La Carmelita (Clinton); Ponce (Holway); Maricao, Yauco (W. & O.).

PUCCINIA SCIRPI DC.

On *Scirpus lacustris*, Guánica (Heller).

PUCCINIA SCLERIAE (Paz.) Arth.

(*Aecidium passifloricola* P. Henn.)

On *Scleria cubensis*, Maricao (W. & O.).

Scleria pterota, Mayagüez, Maricao, El Yunque, Naguabo (W. & O.).

Passiflora rubra, Mayagüez (Stevens); Maricao (W. & O.) (97).

PUCCINIA SCLERIICOLA Arth.

On *Scleria hirtella*, Río Piedras.

Scleria sp., Naguabo (Stevens).

PUCCINIA SMILACIS Schw.

On *Smilax domingensis*, Maricao (W. & O.).

PUCCINIA SPEGAZZINI Det.

On *Mikania scandens*, Mayagüez (W. & O.).

PUCCINIA SUBSTRIATA.

(*Aecidium tubulosum* Pat. & Gaill.)

On *Chaetochloa geniculata*, Río Piedras.

Eriochloa subglabra, Río Piedras, Mayagüez.

Ichnanthus pallens, Mayagüez, El Yunque (W. & O.).

Paspalum glabrum, Vega Baja (Stevens).

Paspalum orbiculatum, Monte de Oro (Stevens).

Paspalum paniculatum, Naguabo, Río Piedras; Mayagüez, Monte Alegrillo (Stevens); Maricao, San Germán (W. & O.).

Paspalum portoricense, Vega Baja.

Paspalum secans, Campo Alegre; Bayamón (Holway).

Syntherisma digitata, Río Piedras; Barceloneta, El Duque (W. & O.).

Valota insularis, Vega Baja, Campo Alegre; Boquerón, San Germán (W. & O.).

Solanum torvum, Río Piedras, Trujillo Alto, Vega Baja; Mayagüez (Heller); San Juan (Holway); Corozal, Yauco, Rosario, El Gigante, Maricao, Lares, Jájome Alto, Monte de Oro, Cayey, Jayuya, Cabo Rojo (Stevens); Utuado (W. & O.) (97).

PUCCINIA SYNEDRELLAE P. Henn.

On *Eleutheranthera ruderalis*, Carolina, Río Piedras; Mayagüez, Aguada (Stevens).

Emilia sonchifolia, Bayamón, Río Piedras, Ponce, Espinosa; Hormigueros, Guayama, Yauco, San Germán (Stevens); Mayagüez, Maricao, Añasco (W. & O.).

PUCCINIA SYNEDRELLÆ P. Henn.—*Continued.*

On *Neurolaena lobata*, Florida Adentro (Stevens).

Synedrella nodiflora, Río Piedras, Trujillo Alto; Barros, Caguas, Cabo Rojo, Santa Catalina, Yauco, Isabela, Rosario, Alegrillo, Lares, San Sebastián, Guayama, Monte de Oro, Jájome Alto, Utuado, Guayanilla (Stevens); Mayagüez, El Duque (W. & O.).

PUCCINIA TAGETICOLA Diet. & Holw.

On *Tagetes erecta*, Maricao (W. & O.).

Tagetes patula, Maricao (Stevens).

PUCCINIA URBANIANA P. Henn.

On *Valerianodes cayennensis*, Santurce.

Valerianodes jamaicensis, Río Piedras, Camuy, Campo Alegre, Naguabo, Añasco; Santurce, Vega Baja, Manatí, Guayama, Dos Bocas (Stevens); San Juan (Earle); Mayagüez (Clinton); Boquerón, San Germán, Barceloneta, Fajardo, Campo Alegre (W. & O.).

Valerianodes strigosa, Cabo Rojo, Mona Island (Stevens); Coamo, Mayagüez (W. & O.).

PUCCINIA XANTHII Schw.

On *Xanthium longirostre*, Santurce.

PUCCINIA ZORNLÆ (Diet.) McAlp.

On *Zornia diphylla*, Río Piedras; Mayagüez (W. & O.).

PUCCINIOSIRA PALLIDULA (Speg.) Lagerh.

On *Triumfetta lappula*, Ponce (Heller) (1).

Triumfetta rhomboidea, Bayamón; Santurce, Aguada, Mayagüez (Stevens).

Triumfetta semitriloba, Mayagüez, Maricao, Yauco (W. & O.).

Triumfetta sp., Río Piedras, Pueblo Viejo, Espinosa; Villa Alba, Mayagüez, Bayamón, Aibonito, Maricao, Rosario, El Gigante, Dos Bocas (Stevens).

RAVENELIA CÆSALPINLÆ Arth.

On *Mimosa ceratonia*, Río Piedras; Bayamón, Vega Baja, Monte Allegrillo, Santa Catalina, Cabo Rojo, Indiera Fría, Aibonito, Vega Alta, San Sebastián, Lares, Manatí, Luquillo Forest, San Germán, El Gigante, Naguabo (Stevens); Mayagüez, Maricao, Barceloneta (W. & O.) (1).

RAVENELIA CASSIÆCOLA Atks.

On *Chamaecrista aeschynomene*, El Gigante (Stevens).

Chamaecrista glandulosa, Vega Baja, Trujillo Alto.

RAVENELIA CAULICOLA Arth.

On *Cracca cinerea*, Cataño, Santurce; Quebradillas, Desecheo (Stevens).

RAVENELIA CEBIL Speg.

On *Piptadenia peregrina*, Peñuelas (Stevens).

RAVENELIA INDIGOFERÆ Tranz.

On *Indigofera suffruticosa*, Cataño, Espinosa; Boquerón, Bayamón, Jayuya, Mayagüez, Aguada (Stevens): Añasco, Yauco, Barceloneta, Naguabo (W. & O.).

RAVENELIA HUMPHREYANA P. Henn.

On *Cæsalpinia pulcherrima*, Río Piedras (94).

RAVENELIA INGÆ (P. Henn.) Arthur.

On *Inga laurina*, Maricao, El Yunque (W. & O.).

Inga vera, Monte Montosa, Monte Alegrillo (Stevens); Ponce (Barret) (1).

RAVENELIA PORTORICENSIS Arth.

On *Cassia emarginata*, Ponce (Heller) (1).

RAVENELIA SILIQUÆ Long.

On *Vachellia Farnesiana*, Yauco, Coamo (W. & O.).

RAVENELIA STEVENSII Arth.

On *Acacia riparia*, Guayanilla, Vega Baja, Peñuelas (Stevens): Coamo (W. & O.).

RAVENELIA WHETZELII Arth.

On *Inga vera*, Maricao, Mayagüez (W. & O.).

TRANZSCHELIA PUNCTATA (Pers.) Arth.

On *Amygdalus persica*, Naguabo; Mayagüez (Earle) (1, 94).

UROMYCES APPENDICULATUS (Pers.) Fries.

On *Phaseolus adenanthus*, Río Piedras; Vega Baja (Stevens): Caguas (Holway): Arecibo (Clinton): Mayagüez, Barceloneta (W. & O.).

Phaseolus lathyroides, Maricao (W. & O.).

Phaseolus vulgaris, Camuy, Barceloneta, Río Piedras; Cabo Rojo (Stevens): Mayagüez (Clinton, Earle); Maricao (W. & O.) (2, 20, 90, 94).

Vigna repens, Río Piedras; Arecibo (Stevens): Mayagüez (W. & O.).

Vigna vexillata, Mayagüez (Stevens).

UROMYCES BIDENTICOLA (P. Henn.) Arth.

On *Bidens leucantha*, Pueblo Viejo, Palo Seco, Vega Baja, Espinosa, Fajardo, Naguabo; Santurce, Aibonito, Añasco, Mayagüez, Monte Alegrillo, Lares, Aguada, Dos Bocas (Stevens); Yauco, Hormigueros, Barceloneta (W. & O.).

Bidens pilosa, Arecibo-Lares, Río Piedras, Río Tanamá, Maricao (Stevens); Boquerón, San Germán (W. & O.).

Cosmos caudatus, Barros, Jayuya (Stevens).

UROMYCES BIDENTIS Lagerh.

(*Uromyces densus* Arthur.)

On *Bidens pilosa*, Ponce (Stevens); Maricao (W. & O.).

UROMYCES CARYOPHYLLINUS (Schrank.) Wint.

On *Dianthus* sp., San Juan (94).

UROMYCES CESTRI Mont.

On *Cestrum laurifolium*, Martín Peña, Camuy; Cabo Rojo, Monte Alegrillo, Quebradillas, San Germán, Arecibo-Lares Road (Stevens); Fajardo, Campo Alegre (W. & O.).

Cestrum macrophyllum, El Duque, Barros, Maricao, Ponce, Monte Alegrillo, Lares, Luquillo Forest, Monte de Oro, Dos Bocas, Naguabo (Stevens); Maricao, Barceloneta, Río Tanamá (W. & O.).

UROMYCES COLOGANIÆ Arth.

On *Teramnus uncinatus*, Cayey (Holway) (2).

UROMYCES COLUMBIANUS Mayor.

On *Melanthera canescens*, Palo Seco, Aibonito, Río Piedras, Espinosa; Ciales, Añasco, Corozal, Yauco, Mayagüez, Vega Baja, Cayey, Cabo Rojo, Rosario, Utuado, Quebradillas, Guayanilla, Dos Bocas, Jayuya (Stevens); Maricao, Barceloneta (W. & O.).

UROMYCES COMMELINÆ (Speg.) Cooke.

On *Commelina virginica*, Desecheo (Stevens).

UROMYCES DOLICHOLI Arth.

On *Cajanus indicus*, Espinosa, Campo Alegre, Río Piedras; Guayanilla, Corozal, Jayuya, Rosario, Mayagüez, Vega Baja, Manatí, Quebradillas (Stevens); Yauco (W. & O.) (81, 90, 94).

Dolicholus minimus, Guánica (W. & O.).

Dolicholus reticulatus, Boquerón, Aguada, Vega Baja (Stevens); Bayamón (Heller); Mayagüez (W. & O.).

UROMYCES ERAGROSTIDIS Tracy.
On *Eragrostis tephrosanthes*, Río Piedras; Bayamón (Stevens); San Germán (W. & O.) (2).

UROMYCES GEMMATUS Berk. & Curt.
On *Jacquemontia nodiflora*, Coamo Springs, Desecheo, San Germán, Guánica, Guayanilla (Stevens); Ponce (Holway).

UROMYCES HEDYSARI-PANICULATI (Schw.) Farl.
On *Meibomia axillaris*, Cabo Rojo (Stevens).
Meibomia scorpiurus, Mayagüez, Peñuelas (Stevens); Yauco (Heller).
Meibomia tortuosum, Sabana Llana; Yauco (W. & O.).

UROMYCES HELLERIANUS Arth.
On *Cayaponia americana*, Sierra de Naguabo; Maricao, Cabo Rojo (Stevens).
Cayaponia racemosa, Río Piedras, Campo Alegre; Corozal (Stevens); Mayagüez, Barceloneta, El Yunque, El Duque (W. & O.) (2).
Melothria guadalupensis, Río Piedras; Yauco, Rosario, Utuado, San Germán (Stevens); Mayagüez, El Duque (W. & O.).

UROMYCES HOWEI Peck.
On *Asclepias curassavica*, Comerío (Holway); Maricao (W. & O.).

UROMYCES IGNOBILIS (Sydow) Arth.
On *Sporobolus indicus*, Río Piedras, Campo Alegre; Mayagüez (Stevens); Naguabo (W. & O.).
Sporobolus virginicus, Camuy (Stevens).

UROMYCES JAMAICENSIS Vestery.
On *Bauhinia pauletia*, San Germán (Stevens); Mayagüez (Holway).

UROMYCES JANIPHÆ (Wint.) Arth.
On *Manihot manihot*, Río Piedras; Vega Baja (Stevens) (81, 90).

UROMYCES LEPTODERMUS Sydow.
On *Lasiacis divaricata*, Espinosa; Coleña, Utuado, San Germán, Maricao, Mona Island (Stevens).
Lasiacis ligulata, Maricao (W. & O.).
Lasiacis Sloanei, Arecibo (Stevens).
Lasiacis sorghoidea, Mayagüez, Maricao (W. & O.).
Panicum barbinode, Carolina, Río Piedras; Guánica, Boquerón, Mayagüez, Peñuelas (Stevens).
Panicum parviflorum, Martín Peña (W. & O.).

UROMYCES NEUROCARPI Dietel.
On *Clitoria cajanifolia*, Mayagüez (Stevens); San Juan (Britton) (2).
Clitoria rubiginosa, Espinosa, Naguabo, Camuy, Santurce, Río Piedras; Dorado (Stevens); Mayagüez, Barceloneta, Martín Peña (W. & O.).

UROMYCES PIANHYENSIS P. Henn.
On *Wedelia reticulata*, San Germán (Stevens); Yauco, Río Tanamá (W. & O.).

UROMYCES PROEMINENS (D. C.) Pass.
On *Chamæsyce brasiliensis*, Mayagüez (W. & O.).
Chamæsyce hirta, Vega Baja, Camuy, Espinosa; Cataño, Vega Baja, Lares, Coamo Springs, Arecibo, Aguada, Guayama, Río Piedras, San Germán, Guayanilla (Stevens); Mayagüez (Clinton); Yauco, San Germán (W. & O.).
Chamæsyce hypericifolia, Fajardo, Río Piedras; Lajas (Stevens).
Chamæsyce prostrata, Río Piedras, Bayamón.

UROMYCES RHYNCOSPORÆ Ellis.
On *Rynchospora distans*, Martín Peña (W. & O.).
Rynchospora micrantha, Naguabo (Stevens).
Rynchospora setacea, Martín Peña (W. & O.) (2).

UROMYCES SCLERIÆ P. Henn.
On *Scleria canescens*, Jájome Alto, El Alto de la Bandera (Stevens); El Yunque (W. & O.).
Scleria pterota, Río Piedras, Vega Baja; Luquillo Forest (Stevens); Mayagüez, Añasco, Naguabo (W. & O.) (2).

UROMYCES SABINEÆ Arth.
On *Sabinea punicea*, Maricao (W. & O.).

FORM-GENUS: ÆCIDIUM.

AECIDIUM ABSCENDENS Arth.
On *Randia aculeata*, Martín Peña, Bayamón; Mayagüez, Cataño, Aguada (Stevens); Barceloneta, Campo Alegre (W. & O.).

AECIDIUM BORRERIÆ Pat.
On *Hemidiodia ocimifolia*, Sierra de Naguabo; Mayagüez (Stevens); El Yunque (W. & O.).

AECIDIUM CIRCUMSCRIPTUM Schw.
See *Endophyllum circumscriptum*.

AECIDIUM DECOLORATUM Schw.
See *Endophyllum decoloratum.*

AECIDIUM EXPANSUM Diet.
See *Endophylloides portoricense.*

AECIDIUM FAVACEUM Arth.
On *Phyllanthus nobilis,* San Germán, Hormigueros (Stevens).

AECIDIUM PASSIFLORICOLA P. Henn.
See *Puccinia scleriæ.*

AECIDIUM TOURNEFORTIÆ P. Henn.
On *Tournefortia bicolor,* Barceloneta (W. & O.).
Tournefortia hirsutissima, Río Piedras; Yauco, Rosario (Stevens).
Tournefortia microphylla, Yauco (W. & O.).

AECIDIUM TUBULOSUM Pat. & Gaill.
See *Puccinia substriatum.*

AECIDIUM WEDELLÆ Earle.
See *Endophyllum wedelia.*

FORM-GENUS: UREDO.

UREDO ÆSCHYNOMENIS Arth.
On *Aeschynomene americana,* Río Piedras, Campo Alegre: Mayagüez, Ponce, Maricao, Rosario, Utuado, Aguada (Stevens).

UREDO ANTHURII Hariot.
On *Anthurium scandens,* El Alto de la Bandera (Stevens).

UREDO ARACHIDIS Lagerh.
On *Arachis hypogea,* Espinosa, Río Piedras, Pueblo Viejo: Dorado (Stevens) (81, 90, 94).

UREDO ARTOCARPI B. & Br.
On *Artocarpus comansi,* Mayagüez (Stevens).
Artocarpus communis, Río Piedras; Mayagüez (Clinton) (1, 81).

UREDO BIXÆ Arth.
On *Bixa orellana,* Adjuntas (Stevens); Maricao (W. & O.).

UREDO CABRERIANA Kern & Kellerm.
On *Erythrina glauca,* Río Piedras, Guaynabo: Bayamón (Holway).

UREDO CLUSIÆ Arth.
On *Clusia rosea,* Maricao (W. & O.).

UREDO COCCOLOBÆ P. Henn.

On *Coccoloba uvifera*, Cataño; Mayagüez, Boquerón, San Germán (W. & O.).

UREDO COMMELYNEÆ Kalchbr.

On *Commelina nudiflora*, Palo Seco.

Commelina virginica, Palo Seco; Coamo Springs (Stevens); Arecibo (Heller); Sabana Llana (Goll).

UREDO CUPHEÆ P. Henn.

On *Cuphea Parsonsia*, Río Piedras; Cabo Rojo (Stevens); Mayagüez, Maricao, Añasco (W. & O.).

UREDO DICHROMENÆ Arth.

On *Dichromena ciliata*, Río Piedras, Sierra de Naguabo; Mayagüez (Clinton).

Dichromena radicans, Guayama (Stevens); Mayagüez, Maricao, Añasco, El Duque, Naguabo (W. & O.).

UREDO DIOSCOREÆ P. Henn.

On *Dioscorea polygonoides*, El Yunque (W. & O.).

Rajania cordata, Río Piedras, Sierra de Naguabo; Bayamón, Jájome Alto, El Gigante, Dos Bocas, Santana (Stevens); Maricao, Río Tanamá, Barceloneta, El Yunque (W. & O.).

UREDO ERYTHROXYLONIS Guz.

On *Erythroxylon areolatum*, Mona Island (Stevens).

URDEO FUIRENÆ P. Henn.

On *Fuirenia umbellata*, Naguabo; Santurce, Aguas Buenas, Mayagüez, Santa Catalina, Cataño (Stevens); Bayamón (Holway); El Yunque (W. & O.).

UREDO GLOBULOSA Arth.

On *Hypoxis decumbens*, Campo Alegre, Río Piedras, Vega Baja; Las Marías, Bandera (Stevens); Maricao, Añasco (W. & O.).

UREDO GOUANIÆ Ellis & Kelsey.

On *Gouania lupuloides*, Garrochales, Camuy, Naguabo, Jájome Alto, Aguadilla, San Germán (Stevens).

Gouania polygama, Guánica (Stevens).

UREDO GUACÆ Mayor.

On *Epidendrum difforme*, Cayey; Jájome Alto (Stevens).

Epidendrum rigidum, Cayey (Holway).

UREDO GYMNOGRAMMES P. Henn.

On *Adiantum latifolium*, Las Marías (Stevens); Mayagüez (W. & O.).

Dryopteris mollis, Mayagüez (W. & O.).

Dryopteris poiteana, Villa Alba (Stevens): Mayagüez, Maricao (W. & O.).

Gomiopteris guadalupensis, Mayagüez (W. & O.).

Pityrogramma calomelana, Maricao (W. & O.).

Tectaria martinicensis, Mayagüez (W. & O.).

UREDO GYNANDREARUM Corda.

On *Habenaria maculosa*, Cataño (Millspaugh): Bayamón (Heller).

Prescottia oligantha, Maricao (W. & O.).

UREDO HAMELIÆ Arth.

On *Hamelia erecta*, Espinosa: Lajas (Stevens): Yauco (W. & O.).

UREDO HELICONIÆ Diet.

See *Puccinia heliconia*.

UREDO HYMENÆÆ Mayor.

On *Hymenaea courbaril*, Martín Peña, Naguabo, Bayamón; Jayuya, Mayagüez, Añasco, Vega Baja (Stevens): Fajardo, Campo Alegre, Coamo (W. & O.).

UREDO JATROPHICOLA Arth.

On *Jatropha curcas*, Hormigueros (Stevens).

Jatropha gossypifolia, Río Piedras, Palo Seco, Martín Peña: San Germán, Guayama, Guayanilla (Stevens): Yauco, Río Tanamá (W. & O.).

UREDO LUTEA Arth.

On *Cassia quinquangulata*, Maricao, Jájome Alto, Naguabo (Stevens); El Yunque (W. & O.).

UREDO NIGROPUNCTATA P. Henn.

On *Bletia patula*, Maricao (Stevens).

UREDO NOTATA Arth.

On *Byrsonima crassifolia*, Mayagüez (W. & O.).

UREDO OLYRÆ P. Henn.

On *Oplismenus hirtellus*, Las Marías (Stevens).

UREDO OPERCULINÆ Arthur.

On *Operculina dissecta*, Yauco (W. & O.).

UREDO PALLIDA Diet. & Holw.

On *Zea mays*, Río Piedras, Punta Cangrejos, Sierra de Naguabo (90, 94).

UREDO PASPALICOLA P. Henn.

(*Uredo Stevensiana* Arth.)

On *Axonopus compressus*, Mayagüez (Stevens).

Bambusa vulgaris, Vega Baja, Espinosa: Maricao, Mayagüez (W. & O.) (94).

Paspalum conjugatum, Espinosa, Río Piedras: Adjuntas (Stevens); Mayagüez, Maricao (W. & O.).

Paspalum glabrum, Mayagüez (Stevens).

Paspalum paniculatum, Vega Baja (Stevens).

Paspalum plicatulum, Río Piedras, Guaynabo: Mayagüez (Stevens); Añasco (W. & O.).

UREDO PIPERIS P. Henn.

On *Peperomia hernandifolia*, El Alto de la Bandera (Stevens).

UREDO PLUCHEA Syd.

(*Uredo biocellata* Arth.)

On *Pluchea odorata*, Ponce, Vega Baja (Stevens); Guánica (Millspaugh).

Pluchea purpurascens, Santurce, Cabo Rojo, Mona Island (Stevens); Mayagüez (W. & O.) (12).

UREDO PROXIMELLA Arth.

On *Lactuca intybacea*, Sabana Grande (Stevens); Barceloneta (W. & O.).

UREDO PUSTULATA P. Henn.

On *Stenorrhynchus lanceolatus*, Las Marías (Stevens).

UREDO RUBESCENS Arth.

On *Dorstenia contrajerva*, Moca; Camuy (Stevens).

UREDO SABICEICOLA Arth.

On *Sabicea aspera*, Mayagüez (Stevens); Maricao (W. & O.).

UREDO SAUVAGESIÆ Arth.

On *Sauvagesia erecta*, Sierra de Naguabo: Jájome Alto (Stevens); El Yunque (W. & O.).

UREDO SPARGANOPHORI P. Henn.

On *Struchium sparganophori*, Carolina: Mayagüez (Stevens).

UREDO SUPERIOR Arth.

On *Fimbristylis ferruginea*, Martín Peña (W. & O.).

Fimbristylis spadicea, Ponce (Heller); Mayagüez (W. & O.).

UREDO TRICHILIA Arth.

On *Trichilia pallida*, Maricao (W. & O.).

UREDO VENUSTULA Arth.

On *Andropogon brevifolius*, Río Piedras; Las Marías (Stevens).

Uredo vicina Arth.

On *Wedelia lanceolata*, Guánica (Stevens).

TREMELLACEÆ.

Auricularia auricula-judæ (L.) Schrt.

(*Hirneola auricula-juda* Berk.)

On rotten wood, Río Piedras, El Duque, Barceloneta, Santana, Fajardo, Caguas, El Yunque, Espinosa, Moca, Mameyes, Dorado; Adjuntas (Sintenis, 76) (82).

Auricularia auriformis (S.) Earle.

(*Exidia auriformis* Fr.)

Reported from the Schwanecke collection (50).

Auricularia delicata (Fr.) Henn.

(*Laschia lamellosa* Pat.)

On dead wood, Río Piedras. Also reported from the Sintenis collection (76), Barceloneta.

Auricularia nigrescens (Sw.) Farlow.

(*Auricularia polytricha* [Mont.] Sacc.)

On dead wood, Espinosa; Vieques (Shafer) (102).

Guepinia palmiceps Berk.

On sugar-cane debris and rotten wood, Río Piedras; Yabucoa (Sintenis, 76) (48).

Guepinia spathulata Schw.

On rotten wood, Río Piedras, Espinosa, Sabana Llana; El Yunque (Stevens) (48, 82).

Tremella fuciformis Berk.

On humus, Bayamón.

Tremella rufolutea Berk.

On rotten wood, El Yunque.

CLAVARIACEÆ.

Clavaria fumosa Pers.

On soil, Martín Peña.

Clavaria inæqualis Mull.

On soil, Río Piedras.

THELEPHORACEÆ.[1]

Asterostroma cervicolor (B. & C.) Massee.

On soil and cane trash, Camuy, Río Piedras (48).

Cladoderris dendritica Pers.

On dead sugar-cane stalk, Río Piedras.

[1] The majority of the determinations in this family by Dr. E. A. Burt.

CORTICIUM ARACHNOIDEUM Berk.
On soil and sugar-cane trash, Río Piedras.

CORTICIUM CONFLUENS Fr.
On dead citrus branch, Campo Alegre (96).

CORTICIUM CONTIGUUM Karst.
On dead wood, Río Piedras.

CORTICIUM DEBILE B. & C.
On dead wood, Río Piedras.

CORTICIUM INVESTIENS (Schw.) Bres.
On dead wood, Río Piedras, Martín Peña.

CORTICIUM KOLEROGA (Cooke) v. Höhn.
(*Pellicularia koleroga* Cooke.)
On *Coffea arabica*, Mayagüez (Thomas). The status of *Pellicularia koleroga* determined by Dr. Burt. ("*Corticiums* causing plant diseases." *In* Ann. Mo. Bot. Garden, v. 5, no. 2, April 1918, p. 119–132.) For additional Porto Rican data see under *Pellicularia*.

CORTICIUM LACTESCENS Berk.
On dead wood, Río Piedras.

CORTICIUM PORTENTOSUM B. & C.
On dead wood, Fajardo, Campo Alegre, Río Piedras, Martín Peña.

CORTICIUM SALMONICOLOR B. & Br.
On *Citrus decumana*, Río Piedras, Trujillo Alto, Garrochales, Espinosa (86, 89, 96).
Citrus sinensis, Pueblo Viejo.
Theobroma cacao, Mayagüez (Fawcett) (30).

CORTICIUM SIMILE B. & C.
On dead sticks, Río Piedras.

CORTICIUM SUBCONTINUUM B. & C.
On dead sticks, Río Piedras.

CORTICIUM TIPHRUM B. & C.
On dead wood, Bayamón.

CORTICIUM VAGUM B. & C.
On *Solanum tuberosum*. Reported by Barrett (6, 15), but occurrence doubtful.

HETEROCHÆTE ANDINA Pat.
On dead sticks, Bayamón.

HYMENOCHÆTE CACAO Berk.
Reported from the Sintenis collection (76).

HYMENOCHÆTE DAMÆCORNIS (Link.) Lev.
On dead wood, Adjuntas (Sintenis) (76).

HYMENOCHÆTE RUBIGINOSA (Schrad.) Lev.
On dead wood, El Duque, Río Piedras.

HYMENOCHÆTE SALLEI Berk.
On dead wood, Espinosa.

HYPOCHNUS PALLESCENS (Schw.) Burt.
(*Corticium pallescens* Schw.)
On dead wood, Río Piedras. The one collection cited by Dr. Burt in Ann. Mo. Bot. Garden. vol. 4. no. 3. Sept. 1917. pp. 267–8.

HYPOCHNUS RUBROCINCTUS Ehbg.
On dead wood, Porto Rico (Stevens) (82).

PENIOPHORA CINEREA Fr.
On dead twigs. and branches of *Citrus* spp.. and other trees. Pueblo Viejo, Espinosa. Bayamón. Río Piedras. Campo Alegre (48. 89, 96).

PENIOPHORA FLAVIDO-ALBA Cooke.
On dead wood and cane trash. Río Piedras. Vega Baja. Sabana Llana (48. 96).

PENIOPHORA GALACHROA Bres.
On dead wood of *Melia azedarach*. Pueblo Viejo.

PENIOPHORA RAVENELII Cooke.
On dead wood. Río Piedras.

SEPTOBASIDIUM LILACINUM Burt.
On trunks of *Citrus decumana*, growing over lichens and debris. Bayamón. Espinosa (96).

SEPTOBASIDIUM PSEUDOPEDICELLATUM Burt.
On living branches. Mayagüez (Earle). Reported by Dr. Burt *in* Ann. Mo. Bot. Garden. vol. 3. no. 3. p. 329. fig. 1. (*Thelephoraceae* of North America. VII.)

SEPTOBASIDIUM SPONGIA (B. & C.) Pat.
Growing over scale insects (*Lepidosaphes beckii*, *Chionaspis citri*) and debris on twigs and branches of *Citrus decumana*, Río Piedras, Espinosa. Pueblo Viejo. Campo Alegre. Garrochales. Vega Baja. Bayamón (94. 96).

STEREUM ALBO-BADIUM Schw.
On dead citrus wood. Vega Baja. Espinosa (96).

STEREUM CAPERATUM Berk & Mont.
On dead wood of *Inga laurina* and other trees. Río Piedras. Manatí.

STEREUM COFFEARUM B. & C.
On dead citrus twigs, Río Piedras (96).
STEREUM ELEGANS Meyer.
On dead wood, Mayagüez (López).
STEREUM FASCIATUM Schw.
On dead wood, Río Piedras, Bayamón, El Yunque, Comerío.
STEREUM LOBATUM Fr.
On dead wood, Río Piedras, San Patricio (Sintenis) (76).
STEREUM PAPYRINUM Mont.
On dead wood, Espinosa.
STEREUM STRUMOSUM Fr.
On dead wood, Bayamón.
STEREUM TUBERCULOSUM Fr.
On dead wood, Río Piedras.
STEREUM UMBRINUM B. & C.
On dead wood, Río Piedras.
THELEPHORA MULTIFIDA Klotzsch.
Reported from the Schwanecke collection (50).
THELEPHORA SERICELLA B. & C.
On soil, Río Piedras, Martín Peña, Espinosa.
TREMELLODENDRON SIMPLEX Burt.
On soil, in cane field. Described in Ann. Mo. Bot. Garden, vol 2, no. 4, pp. 742–3, from collection by Johnston (48).

HYDNACEÆ.

HYDNUM MULTIFIDUM (Klotzsch) P. Henn.
Reported from the Sintenis collection (76), on dead wood, Adjuntas.
HYDNUM SACCHARI Spreng.
On dead cane trash, Río Piedras (48).
IRPEX DISCOLOR Berk.
On rotten wood, Río Piedras.
IRPEX FARINACEA Fries.
(*Cerrenella farinacea* [Fries.] Murrill.)
(*Poria portoricensis* Fries.)
Reported from Porto Rico (65).
IRPEX FLAVUS Klotsch.
Reported from the Sintenis collection (76).
IRPEX LACTEUS Fries.
(*Irpiciporus lacteus* [Fries] Murrill.)
On dead wood, Bayamón, Río Piedras, Pueblo Viejo (65, 82).

ODONTIA SACCHARI Burt.

On *Saccharum officinarum*, Río Piedras (13, 48, 105).

ODONTIA SACCHARICOLA Burt.

On *Paspalum* sp., Río Piedras.

Saccharum officinarum, Río Piedras, Canóvanas, Cambalache, Camuy (13, 48, 105).

ODONTIA WRIGHTII (B. & C.) Pat.

On dead wood, El Duque.

POLYPORACEÆ.

DÆDALEA REPANDA Pers.

(*Dædalea amanitoides* Beauv.)

On dead wood, El Yunque, Santurce, Río Piedras, Moca, Juncos, Mameyes, Vega Baja, Martín Peña, Espinosa; Mona (12), Monte Alegrillo, Cabo Rojo (Stevens) (82). Reported from the Sintenis collection (76) as *Trametes elegans* (Spr.) Fr.

FAVOLUS BRAZILIENSIS Fr.

(*Hexagona Wilsonii* Murrill.)

(*Hexagona dædalea* [Link] Murrill.)

On dead wood, El Duque, Aibonito, Mameyes; Monte Alegrillo (Stevens) (62, 82). Reported from the Sintenis collection (76) as *Favolus hispidulus* Berk.

FAVOLUS PORTORICENSIS (Murr.) Sacc.

(*Hexagona portoricensis* Murrill.)

Reported and named from Porto Rico by Murrill (62, 65).

FAVOLUS PSEUDOPRINCEPS (Murr.) Sacc.

(*Hexagona pseudoprinceps* Murrill.)

On dead wood, Carmelita (Earle) (61, 62).

FOMES AUSTRALIS Fr.

(*Fomes fasciatus* Lev.)

(*Elfvingia tornata* [Pers.] Murrill.)

On dead wood, Bayamón, Río Piedras, Mameyes, Martín Peña, El Duque; Monte Alegrillo (Stevens) (82). Reported as *Ganoderma australe* (Fr.) Pat. from the Sintenis collection (76).

FOMES BADIUS Berk.

(*Fulvifomes Underwoodii* Murrill) (65).

(*Pyropolyporus Underwoodii* Murrill.)

On dead wood, Palo Seco (62).

FOMES CALCITRATUS Berk & Curt.

(*Fulvifomes calcitratus* [Berk & Curt.] Murrill.)

(*Pyropolyporus calcitratus* [Berk. & Curt.] Murrill.)

On dead wood. Col. N. Y. Bot. Garden (62, 65).

FOMES DEPENDENS Murrill.

(*Fulvifomes dependens* Murrill.)

(*Pyropolyporus dependens* Murrill.)

On dead wood and sometimes as a cause of heart rot of hardwood trees, Vieques (Shafer); Mona Island (Britton) (12, 82, 102).

FOMES EXTENSUS Lev.

(*Fulvifomes extensus* [Lev.] Murrill.)

(*Pyropolyporus extensus* [Lev.] Murrill.)

On dead wood, Pueblo Viejo.

FOMES IGNIARIUS (L.) Fr.

(*Pyropolyporus igniarius* [L.] Murrill.)

Reported from the Sintenis collection (76). Probably *Fomes extensus.*

FOMES LAMAENSIS Murrill.

On dead wood. Martín Peña.

FOMES LIGNEUS (Berk.) Cooke.

Reported from the Sintenis collection (76).

FOMES LIGNOSUS Klotzsch.

(*Fomes auberianus* [Mont.] Murrill.)

On dead wood, Mameyes, El Duque, Pueblo Viejo, Río Piedras; Mayagüez (López); Maricao (Stevens) (82).

FOMES LINTEUS Berk.

On dead wood, Río Piedras. Determined by Dr. Murrill as *Fomes* (*Fulvifomes*) *extensus.*

FOMES MARMORATUS Berk.

(*Elfvingia fasciata* [Sw.] Murrill.)

(*Elfvingiella fasciata* [Sw.] Murrill.)

(*Fomes fasciatus* Schwartz.)

On dead wood, Naguabo, Moca, Bayamón, Aibonito, Río Piedras, Manatí, Fajardo, Mameyes, Comerío; Monte Alegrillo (Stevens) (82). Reported from the Sintenis collection (76) as *Fomes fomentarius* (L.) Fr.

LASCHIA PEZIZOIDES B. & C.

On dead wood, Río Piedras.

LENZITES STRIATA Fr.

(*Glœophyllum striatum* [Fr.] Murrill.)

On dead wood, Río Piedras, Humacao, Bayamón, Caguas, Camuy, Espinosa, Santana; Mona Island (12); Vieques (Shafer) (82, 102).

MERULIUS BYSSOIDEUS Burt.

On soil and cane trash, Río Piedras (48). Described by Dr. Burt in Ann. Mo. Bot. Garden, v. 4, no. 4, Nov. 1917, pp. 358–9, fig. 1. Collection by J. R. Johnston.

MERULIUS RUGULOSUS B. & C.

(*Corticium saccharinum* B. & C.)

On dead wood, Bayamón.

MERULIUS SULPHUREUS Burt.

On rotten wood and bark, Bayamón.

POLYPORUS AMBOINENSE Fr.

Reported as *Ganoderma amboinense* (Lam.) Pat. from the Sintenis collection (76). "The determination is in all probability wrong. Known only from the Philippines, although applied to many tropical plants, related to *Polyporus lucidus.*"—Lloyd.

POLYPORUS ANEBUS Berk.

On dead wood, Maneye .

POLYPORUS BLANCHETIANUS Mont.

Reported from the Sintenis collection (76). Given by Lloyd as practically a form of *P. varius.*

POLYPORUS CHAPERI (Pat.)

(*Amauroderma Chaperi* [Pat.] Murrill.)

On dead wood, Santa Isabel (65).

POLYPORUS CONCHOIDES Mont.

Reported as *Glœoporus conchoides* Mont. from the Sintenis collection (76).

POLYPORUS CONCRESCENS Mont.

(*Rigidoporus evolutus* [Berk. & Curt.] Murrill

On dead wood. Coll. N. Y. Bot. Garden (65).

POLYPORUS DEALBATUS B. & C.

(*Microporellus dealbatus* [B. & C.] Murrill.)

On dead wood, Porto Rico (Stevens) (82).

POLYPORUS DISTORTUS Schw.

(*Abortiporus distortus* [Schw.] Murrill.)

On dead wood. Coll. N. Y. Bot. Garden (65).

POLYPORUS FIMBRIATUS Fr.

Reported from the Sintenis collection (76) as *P. Warmingii* Berk.

POLYPORUS FLAVESCENS Mont.

(*Tyromyces albogilvus* [Berk. & Curt.] Murrill.)

On dead trunks. Coll. N. Y. Bot. Garden (65).

POLYPORUS FLAVIPORUM Murrill.

(*Amauroderma flaviporum* Murrill.)

On dead wood, Cortada.

POLYPORUS FRUCTICUM Berk.

(*Inonotus corrosus* Murrill.)

On dead wood, Mona Island (Britton); Vieques (Shafer) (12, 65, 82, 102).

POLYPORUS FULVELLUS Bres.

(*Ganoderma nitidum* Murrill.)

On dead wood, Garrochales, Río Piedras.

POLYPORUS GILVUS Schw.

(*Hapalopilus gilvus* [Schw.] Murrill.)

On dead wood, Pueblo Viejo, Moca, Aibonito, El Yunque, Vega Baja, El Duque, Río Piedras; Maricao (Stevens); Vieques (Shafer) (82, 102). Reported from Cayey in the Sintenis collection (76) as a variety, *scruposus*.

POLYPORUS GRACILIS Kl.

(*Polyporus obolus* Ellis & Macbr.) (65).

(*Polyporus Cowellii* Murrill.)

On dead wood. Coll. N. Y. Bot. Garden (62, 65).

POLYPORUS HAVANNENSIS Berk.

(*Trametes havannensis* [Berk.] Murrill.)

On dead wood, Porto Rico (Stevens) (82). Probably referable to *Polyporus subfulvus* Berk.

POLYPORUS HEMILEUCUS Berk & Curt.

Reported from the Sintenis collection (76). Referable to *P. sapinus*, or possibly *P. modestus*.

POLYPORUS LEPRIEURII Mont.

Reported from the Sintenis collection (76).

POLYPORUS LICNOIDES Mont.

(*Hapalopilus licnoides* [Mont.] Murrill.)

On dead wood, Fajardo, Martín Peña, El Duque, Palo Seco, Comerío, Río Piedras; Maricao (Stevens) (82).

POLYPORUS LUCIDUS Leys.

Reported as *Ganoderma lucidum* (Leys.) Pat. from the Sintenis collection (76).

POLYPORUS MARBLEÆ Murrill.

On dead wood, Utuado. Coll. N. Y. Bot. Garden (65).

POLYPORUS MODESTUS Kze.

On dead wood, Fajardo (Schwanecke) (50).

POLYPORUS NIVOSELLUS Murrill.

(*Tyromyces nivosellus* Murrill.)

Reported from Porto Rico in North Amer. Flora (62, 65).

POLYPORUS OBTUSUS Berk.

(*Spongipellis unicolor* [Schw.] Murrill.)

Reported from Humacao in the Schwanecke collection (50) as *Polyporus unicolor* Schw.

POLYPORUS PAPYRACEUS Fries.

Reported in North American Flora. Probably *Polystictus membranaceus* (62).

POLYPORUS PERZONATUS Murrill.

(*Ganoderma perzonatum* Murrill.)

On dead wood. Coll. N. Y. Bot. Garden (65).

POLYPORUS PUSILLUS Persoon.

(*Favolus rhipidium* Berk.)

(*Favolus subpulverulentus* Berk & Curt.)

(*Inonotus pusillus* [Pers.] Murrill.)

On dead and rotten wood, Pueblo Viejo, Martín Peña, Río Piedras, Comerío; Monte Alegrillo (Stevens) (82). Also reported from the Sintenis collection (76).

POLYPORUS RUGULOSUS Lev.

Reported from Cayey in the Sintenis collection (76). "Very close to and practically the same plant as *Polyporus zonalis* Berk."—Lloyd.

POLYPORUS SEMILACCATUS Berk.

On dead wood, Palo Seco.

POLYPORUS SUBFULVUS Berk.

(*Coriolus ochrotinctellus* Murrill.)

On dead wood, Espinosa, Bayamón, Guaynabo, Río Piedras (65, 82).

POLYPORUS SULPHUREUS (Bull.) Fr.

(*Laetiporus speciosus* [Batt.] Murrill.)

Reported from Lares in the Sintenis collection (76).

POLYPORUS SUPINUS Swartz.

(*Fomitella supina* [Sw.] Murrill.)

On dead wood, Arecibo, Santana, Moca, El Duque.

POLYPORUS TRICHOLOMA Mont.

On dead wood, Martín Peña, Río Piedras, El Duque, Espinosa; Humacao (Schwanecke) (50).

POLYPORUS VARIIPORUS Murrill.

On dead sticks (62, 65).

POLYPORUS VINOSUS Berk.

(*Nigroporus vinosus* [Berk.] Murrill.)

On dead wood, Sierra de Naguabo.

POLYPORUS ZONALIS Berk.

(*Rigidoporus surinamensis* [Miq.] Murrill.)

On dead wood, Río Piedras, Espinosa, Guaynabo, Fajardo, Palo Seco; El Alto de la Bandera, Monte Alegrillo (Stevens) (82).

POLYSTICTUS ARMENICOLOR Berk & Curt.

(*Coriolus armenicolor* [Berk. & Curt.] Pat.)

On dead wood, Río Piedras (65).

POLYSTICTUS CROCATUS Fries. (?).

(*Coriolopsis crocata* [Fries.] Murrill.)

On dead wood, Porto Rico (Stevens) (82).

POLYSTICTUS DRUMMONDII Klotzsch.

(*Coriolus Drummondii* [Klotzsch] Pat.)

On dead wood, Bayamón; Mayagüez (Stevens) (82).

POLYSTICTUS ELONGATUS Berk.

On dead wood, Río Piedras. Also reported from the Sintenis collection (76).

POLYSTICTUS FULVOCINEREUS Murrill.)

(*Coriolopsis fulvocinerea* Murrill.)

On dead wood, Martín Peña.

POLYSTICTUS HEDINUS Berk.

(*Coriolus hadinus* [Berk.] Pat.)

On dead wood. Coll. N. Y. Bot. Garden (62, 65).

POLYSTICTUS HIRSUTUS Fr.

(*Coriolus nigromarginatus* [Schw.] Murrill.)

Reported from Barranquitas (Sintenis) (76).

POLYSTICTUS HIRTELLUS Fr.

(*Coriolus nigromarginatus* [Schw.] Murrill.)

On dead wood, Martín Peña, Río Piedras.

POLYSTICTUS HOLLICKII Murrill.

(*Coriolus Hollickii* Murrill.)

On dead wood, Monte Alegrillo (Stevens) (65, 82).

POLYSTICTUS MAXIMUS Mont.

(*Coriolus maximus* [Mont.] Murrill.)

On dead wood, Moca, Martín Peña, Manatí, Espinosa, Río Piedras; Vieques (Shafer); Cabo Rojo (Stevens) (82, 102).

POLYSTICTUS MEMBRANACEUS Sw.

(*Coriolus membranaceus* [Sw.] Pat.)

On dead wood, Bayamón, Martín Peña, Espinosa, Pueblo Viejo, El Yunque, Comerío; Monte Alegrillo (Stevens) (82). Reported from the Sintenis collection (76).

POLYSTICTUS OCCIDENTALIS Klotzsch.

(*Coriolopsis occidentalis* [Kl.] Murrill.)

On dead wood, Martín Peña, Fajardo, Palo Seco, Río Piedras, El Yunque, Vega Baja, Barceloneta, Bayamón, Guaynabo; Barceloneta (Sintenis, 76) (48, 82, 96).

POLYSTICTUS PAVONIUS Hook.

(*Coriolus pavonius* [Hook.] Murrill.)

On dead wood, Bayamón, Río Piedras, Mameyes, El Yunque Fajardo (82).

POLYSTICTUS PINSITUS Fries.

(*Coriolus pinsitus* [Fries] Murrill.)

On dead wood, Río Piedras, Martín Peña, Bayamón, Espinosa, Campo Alegre, Barceloneta, Garrochales, Mameyes, Vega Alta, El Yunque; Utuado, Monte Alegrillo, Vega Baja, (Stevens) (82, 96); Mona (12); Vieques (Shafer) (102). Reported from Utuado in the Sintenis collection (76) as *P. umbonatus* Fr.

POLYSTICTUS POLYZONUS Pers.

On dead wood, Río Piedras.

POLYSTICTUS RIGENS Sacc. & Cub.

(*Coriolopsis rigida* [Berk. & Mont.] Murrill.)

On dead wood, Sardinera (12, 82); Río Piedras, Martín Peña, Pueblo Viejo, El Duque, Campo Alegre, El Yunque, Santana, Arecibo, Bayamón.

POLYSTICTUS SANGUINEUS L.

(*Pycnoporus sanguineus* [L.] Murrill.)

On dead wood, Martín Peña, Río Piedras, El Yunque, Sierra de Naguabo, Espinosa, Palo Seco, Dorado; Añasco (Stevens) (82). Also reported from the Sintenis and Schwanecke collections (50, 76), Mona Island (12), and Vieques (102)

POLYSTICTUS SINUOSUS B. & C.
(*Poria sinuosa* Fr.)
On dead cane stalks and rotten wood, Río Piedras, Gurabo, Bayamón (48, 53). Both the pileate and resupinate forms occur.

POLYSTICTUS SPATHULATUS Hook.
(*Polyporus multiformis* Mont.)
(*Coltricia spathulata* [Hook.] Murrill.)
On dead wood, Martín Peña.

POLYSTICTUS STEREINUS B. & C.
(*Rigidoporus Liebmanni* [Fries.] Murrill.)
On rotten wood, El Yunque (62).

POLYSTICTUS SUBGLABRESCENS Murrill.
(*Coriolopsis subglabrescens* Murrill.)
On dead wood. Coll. N. Y. Bot. Garden (62, 65).

POLYSTICTUS VELUTINUS Fr.
Reported from Humacao in the Schwanecke collection (50).

POLYSTICTUS VERSICOLOR L.
(*Coriolus versicolor* [L.] Quel.)
On dead wood, Mayagüez (Stevens) (82).

PORIA AURANTIOTINGENS Ellis & Macbr.
(*Tinctoporia aurantiotingens* [Ell. & Macbr.] Murrill.)
On dead wood, Río Piedras, El Duque.

PORIA VINCTA Berk.
On dead wood, Río Piedras.

TRAMETES CUBENSIS (Mont.) Sacc.
On dead wood, Espinosa, El Duque, Martín Peña.

TRAMETES HYDNOIDES Sw.
(*Pogonomyces hydnoides* [Sw.] Murrill.)
On dead wood, Martín Peña, Moca, Espinosa, Caguas, Arecibo, Mona Island (12); Monte Alegrillo (Stevens) (82). Also reported from the Sintenis collection (76).

TRAMETES NIVOSA (Berk.) Murrill.
On dead cane stalks, Río Piedras (48).

TRAMETES SUBMURINA Murrill.
On rotten wood, Espinosa, Palo Seco, Río Piedras, Santurce.

TRAMETES TAYLORI Murrill.
(*Coriolopsis Taylori* Murrill.)
On dead wood, Naguabo, Vega Baja (62, 65).

AGARICACEÆ.

Agaricus Johnstonii Murrill.
On humus. Río Piedras (68).

Amphalia lapidescens (Hor.) Cohn & Schrot.
Reported from the Sintenis collection (76).

Atylospora byssina Murrill.
On dead wood. Río Piedras (67).

Campanularis campanulatus (L.) Earle.
On manure. Río Piedras (Fink.) (67).

Campanularis solidipes (Peck) Murrill.
On horse manure. Río Piedras; Utuado (Britton and Cowell); Mayagüez. Aibonito (Fink) (67).

Cortinarius Sintenisii P. Henn.
Reported from the Sintenis collection (76).

Galera tener (Schaeff.) Quel.
On humus. Río Piedras.

Gymnopilus Earlii Murrill.
On dead wood. Mayagüez (Thomas and López).

Gymnopus tenuipes (Schw.) Murrill.
On dead wood. reported in N. Amer. Flora (66).

Heliomyces subavellaneus Murrill.
On dead wood. Río Piedras (Shafer) (64).

Lentinula detonsa (Fries) Murrill.
On dead wood. Coll. N. Y. Bot. Garden (63).

Lentinus crinitus (L.) Fries.
On dead wood and cane stalks. Río Piedras. Pueblo Viejo. Moca. Campo Alegre. Martín Peña. El Duque; Cayey (Stevens) (48. 82). Also reported from Mona Island (12). and from the Sintenis collection (76). Recorded in the Schwanecke collection as *Lentinus nigripes* Fr. (50).

Lentinus hirtus (Fries) Murrill.
On dead wood. Río Piedras. Espinosa. Pueblo Viejo. Caguas. El Yunque. Gurabo. El Duque. Mameyes (63. 82).

Lentinus lepideus Fries.
(*Lentodium squamosum* [Huds.] Murrill.)
On rotten wood. Río Piedras (63. 82).

Lentinus scyphoides Pat.
On dead wood. Río Piedras.

LENTINUS STRIGELLUS Berk & Curt.
On dead wood. Col. N. Y. Bot. Garden (63).

LENTINUS STRIGOSUS (Schw.) Fries.
On dead wood. Moca, Río Piedras, Santana; Cabo Rojo (Stevens); Vieques (82, 102). Also from the Sintenis collection (76) as *L. Lecomtei* Fr.

LENTINUS SUBSCYPHOIDES Murrill.
On dead wood, Río Piedras (64).

LENTINUS VELUTINUS Fries.
On dead wood, Santana.

LEPIOTA CEPAESTIPES (Sow.) Quel.
On humus, Martín Peña, Río Piedras.

LEPIOTA CRETACEA (Bul.) Murrill.
On soil in cane fields, Río Piedras.

LEPIOTA MORGANI Peck.
(*Chlorophyllum molybdites* Mass.)
On humus, Bayamón, Río Piedras.

LEPIOTA RUBROTINCTA Pk. (?).
Reported by Stevens (82).

MARASMIUS BERTEROI (Lev.) Murrill.
On trunks of trees (64).

MARASMIUS BORINQUENSIS Stevenson.
On dead sugar-cane stalks, Río Piedras (48).

MARASMIUS CINEREIALBUS Murrill.
On leaf mold, Río Piedras (64).

MARASMIUS HIORAMI Murrill.
On dead and dying sugar-cane leaves and roots, Río Piedras (48, 64).

MARASMIUS JOHNSTONII Murrill.
On dead leaves, Río Piedras (64).

MARASMIUS OBSOLETUS Murrill.
On dead wood, Río Piedras (64).

MARASMIUS PALLESCENS Murrill.
On dead leaves, Río Piedras (64).

MARASMIUS PAUCIFOLIUS Murrill.
On dead leaves. Río Piedras (64).

MARASMIUS PECKII Murrill.
On dead leaves (64).

MARASMIUS PORTORICENSIS Murrill.
On leaf mold, Río Piedras (64).

MARASMIUS SACCHARI Wakker.

On *Andropogon bicornis*, Río Piedras.

Bromelia pinguin, Río Piedras.

Panicum barbinode, Cambalache. Patillas.

Saccharum officinarum, Ponce. Fortuna. Río Piedras. Canóvanas, Mameyes (22, 23, 38, 40, 41, 48, 59, 91, 94, 105).

MARASMIUS SYNODICUS (Kunze) Fries.

On dead leaves and grass, Río Piedras (64).

MARASMIUS WILSONII Murrill.

On dead leaves. Luquillo (Wilson) (64).

MELANOTUS FUMOSIFOLIUS Murrill.

On rotten wood, Utuado (Britton and Marble) (67).

OMPHALOPSIS EUSPEIREA (Berk. & Curt.) Murrill.

On dead wood (66).

PANELLUS EUGRAMINUS (Mont.) Murrill.

On dead wood, El Duque. Río Piedras.

PLICATURA OBLIQUA (B. & C.) Murrill.

On dead wood. Bayamón. Río Piedras, El Yunque, Martín Peña.

POLYMARASMIUS SARMENTOSUS (Berk.) Murrill.

On dead wood (64).

PSATHYRELLA MINUTULA (Schaeff.) Murrill.

(*Psathyrella disseminata* Quel.)

On humus. El Yunque. Río Piedras.

PSATHYRELLA STEVENSONII Murrill.

On garden soil. Río Piedras (67).

SCHIZOPHYLLUM COMMUNE Fr.

(*Schizophyllum alneum* [L.] Schroet.)

(*Schizophyllus alneus* [L.] Schröet.)

On *Citrus decumana*, Río Piedras. Fruit rot, and wood rot of trunk and limbs (89, 96).

Ipomœa batatas, Río Piedras.

Saccharum officinarum (dead and dying stalks), Río Piedras. Plazuela (20, 38, 48, 105). Common everywhere on dead wood, Yabucoa. Carolina, Bayamón; Maricao, Cataño, El Gigante (Stevens) (82); Mona Island (12); Vieques (102); Adjuntas (Sintenis) (50, 76); Santurce Heller) (19).

SCYTINOTUS DISTANTIFOLIUS Murrill.

On dead wood, grass and sugar-cane leaves, Río Piedras (48, 64).

STROPHARIA CUBENSIS Earle.
On manure, various localities (Britton and Marble) (Fink) (68)

PHALLACEÆ.

CLATHRUS CANCELLATUS Tournef.
Porto Rico (Sintenis) (76). Probably should be referred to the following species.

CLATHRUS CRISPUS Turpin.
On garden soil, Santurce.

LATERNEA COLUMNATA Nees.
Sintenis, from Porto Rico. Reported (76) as *Clathrus columnatus*.

LATERNEA TRISCAPA Turpin.
On garden soil. Río Piedras.

MUTINUS CANINUS (Huds.) Fr.
Reported by Johnston at Río Piedras.

PHALLUS INDUSIATUS Vent.
On soil. Mayagüez (Brandes); Río Piedras, Martín Peña; Adjuntas (Sintenis) (76) as *Dictyophora phalloidea*.

LYCOPERDACEÆ.

GEASTER MIRABILIS Mont.
On forest soil, Martín Peña; Adjuntas (Sintenis) (76).

GEASTER SACCATUS Fr.
On humus, Río Piedras.

GEASTER VELUTINUS Morgan.
On humus, Río Piedras.

LYCOPERDON ALBIDUM Cooke.
On dead cane stalks and debris, Cortada, Río Piedras (48, 52).

LYCOPERDON CRUCIATUM Rostk.
On soil and rotten wood, Río Piedras, Palo Seco.

LYCOPERDON PUSILLUM Batsch.
On humus and cane trash, Pueblo Viejo, Río Piedras (48).

LYCOPERDON PYRIFORME Schaeff.
(*Lycoperdon rubellum* Beck.)
On soil, Río Piedras, Barceloneta (48).

TYLOSTOMA EXASPERATUM Mont.
On dead wood, Lares (Sintenis) (76).

NIDULARIACEÆ.

CYATHUS EARLEI Lloyd.

On dead wood, Sabana Llana, Palo Seco.

CYATHUS PALLIDUS Berk.

On dead wood, Martín Peña, Río Piedras.

CYATHUS PŒPPIGII Tulasne.

On dead cane stalks and dead wood, Río Piedras, Fajardo (48).

CYATHUS STERCOREUS Schw.

On manure, Río Piedras.

CYATHUS STRIATUS Hudson.

(*Nidularia striata* Bull.)

Reported from the Schwanecke collection (50), but would doubtless be found to be *C. pæppigii* if reexamined.

SPHÆROBOLUS STELLATUS Tode.

On cane trash and rotten wood, Río Piedras (48).

FUNGI IMPERFECTI.

PHOMATACEÆ.

ACTINONEMA ROSÆ (Lib.) Fr.

On leaves of *Rosa* sp., Río Piedras (94).

ASCOCHYTA NICOTIANÆ Pass.

On *Nicotiana tabacum* (8).

CINCINNOBOLUS CESATII De By.

On *Erysiphe polygoni* (?) on *Cassia tora*, San Germán (Stevens) (82).

CRYPTOSTICTIS HYSTERIOIDES Fuckel.

On dead leaves, Río Piedras.

CYTOSPORA SACCHARI Butler.

On dead and dying sugar-cane leaf-sheaths and stalks, Río Piedras, Carolina, Fajardo (48, 84, 105).

DARLUCA FILUM (Biv.) Cast.

On *Kuehneola gossypii* on *Gossypium barbadense* (Stevens).
Puccinia cannæ on *Canna* sp. (Stevens).
Puccinia eleocharidis on *Eleocharis* sp., Mayagüez (Stevens).
Puccinia gonaniæ on *Gouania*, Utuado (Stevens).
Puccinia Huberi on *Panicum trichoides*, Jayuya (Stevens).
Puccinia lantanæ on *Lantana involucrata*, Quebradillas.
Puccinia polygoni-amphibii on *Persicaria punctata*, Río Piedras.

DARLUCA FILUM (Biv.) Cast.—*Continued.*
On *Puccinia rivina* on *Rivina humilis,* Desecheo (Stevens).
Puccinia substriata on *Eriochloa subglabra,* Mayagüez (Stevens).
Uredo æschynomenis on *Aeschynomene americana* (Stevens).
Uromyces leptodermus, on Lasiacis divaricata and *Panicum barbinode* (Stevens) (82).
Rust (undet.) on *Kyllingia* sp. (Sintenis) (76).

DIPLODIA CACAOICOLA P. Henn.
On *Saccharum officinarum,* Río Piedras, Vieques, Las Monjas, (48, 94, 105).
Theobroma cacao, Mayagüez (20).

DIPLODIA NATALENSIS Evans.
On *Citrus* spp., as a fruit rot, twig blight, and trunk canker, Río Piedras, Garrochales, Palo Seco, Pueblo Viejo, Espinosa, Bayamón, Campo Alegre (29, 58, 84, 89, 94, 96).

DIPLODIA OPUNTIÆ Sacc.
On *Opuntia* sp., Guánica (84).

DIPLODIA TUBERICOLA (E. & E.) Taub.
On *Ipomœa batatas,* Río Piedras.

PHOMA DESTRUCTIVA Plowr.
On *Lycopersicum esculentum,* Río Piedras (90, 94).

PHOMA FOURCROYÆ Thüm.
On *Furcrea tuberosa,* Espinosa, Bayamón.

PHOMOPSIS CITRI Faw.
On *Citrus decumana,* Trujillo Alto, Bayamón, Palo Seco (89, 96).
Citrus sinensis, Bayamón (89, 96).

PHOMOPSIS VEXANS (Sacc. & Syd.) Harter.
On *Solanum melongena,* Río Piedras (90, 94).

PHYLLOSTICTA ADIANTICOLA Young.
On *Adiantum tenerum,* Río Piedras, Camuy; Manatí, Utuado, Quebradillas (Stevens) (103).

PHYLLOSTICTA APII Hals.
On *Apium graveolens,* Río Piedras.

PHYLLOSTICTA ARALIANA Young.
On *Dendropanax arboreum,* Maricao (Stevens) (103).

PHYLLOSTICTA BATATAS E. & M.
On *Ipomœa batatas,* Río Piedras (90).

PHYLLOSTICTA BIXINA Young.
On *Bixa orellana*, Bayamón, Espinosa, Río Piedras; Maricao, San Germán, Rosario, Mayagüez, Coamo, Añasco, Adjuntas (Stevens) (103).

PHYLLOSTICTA BORINQUENSIS Young.
On *Helicteres jamaicensis*, Palo Seco, Martín Peña; San Germán (Stevens) (103).

PHYLLOSTICTA CISSICOLA Speg.
On *Cissus sicyoides*, Río Piedras; Vega Baja, Jájome Alto (Stevens) (103).

PHYLLOSTICTA CITRULLINA Chester.
On *Cucurbita melo*, Río Piedras (90).

PHYLLOSTICTA CLUSIÆ Stevens.
On *Clusia rosea*, Maricao (Stevens) (82).

PHYLLOSTICTA COCCOLOBÆ E. & E.
On *Coccoloba uvifera*, Mona Island (Stevens) (103).

PHYLLOSTICTA COLOCASIÆ Höhnel.
On *Dieffenbachia seguine*, Monte de Oro (Stevens) (90, 103).

PHYLLOSTICTA COLOCASICOLA Höhnel.
On *Colocasia* sp., Caguas (Stevens) (103).

PHYLLOSTICTA COMMELINICOLA Young.
On *Commelina nudiflora*, Río Piedras, Trujillo Alto; Hormigueros (Stevens) (103).

PHYLLOSTICTA CUCURBITACEARUM Sacc.
On *Cucumis sativus*, Río Piedras (90).

PHYLLOSTICTA DIVERGENS Sacc.
On *Albizzia lebbeck*, Porto Rico (Stevens) (103).

PHYLLOSTICTA ERYTHRINICOLA Young.
On *Erythrina micropteryx*, Aibonito; Villa Alba, Jájome Alto, Yauco, Mayagüez (Stevens) (103).

PHYLLOSTICTA EUGENIÆ Young.
On *Eugenia buxifolia*, Mona Island (Stevens) (103).

PHYLLOSTICTA EUPATORICOLA Rab. & Bub.
On *Eupatorium odoratum*, Río Piedras, Sierra de Naguabo; Villa Alba (Stevens) (103).

PHYLLOSTICTA GLAUCISPORA Delacr.
On *Urechites lutea*, Porto Rico (Stevens) (103).

PHYLLOSTICTA GUANICENSIS Young.
On *Guilandina crista*, Guánica (Stevens) (103).

PHYLLOSTICTA GUAREÆ P. Henn.
On *Guarea trichilioides*, Aguas Buenas (Stevens) (103).

PHYLLOSTICTA HORTORUM Speg.
See *Phomopsis vexans.*

PHYLLOSTICTA HYBISCINA E. & E.
On *Abutilon umbellatum*, Mona Island (Stevens) (82).

PHYLLOSTICTA IPOMŒÆ Ell. & Keller.
On *Exogonium repandum*, Manatí, Mayagüez, Río Piedras, Dos Bocas (Stevens) (103).

PHYLLOSTICTA LANTANÆ Stevens.
On *Lantana odorata*, Desecheo, Mona, Utuado, Guánica (Stevens) (82).

PHYLLOSTICTA MOMISIANA Young.
On *Momisia iguanaca*, Coamo (Stevens) (103).

PHYLLOSTICTA MACULICOLA Hals.
On *Cordyline terminalis*, Río Piedras, Sabana Llana.

PHYLLOSTICTA PANDANICOLA Young.
On *Pandanus* sp., Santurce (Stevens) (103).

PHYLLOSTICTA PANICI Young.
On *Panicum maximum*, Río Piedras; Coamo, Martín Peña (Stevens) (103).

PHYLLOSTICTA PITHECOLOBII Young.
On *Pithecolobium unguis-cati*, Desecheo, Yauco (Stevens) (103).

PHYLLOSTICTA PITHECOLOBII var. MONENSIS Young
On *Pithecolobium unguis-cati*, Mona Island (Stevens) (103).

PHYLLOSTICTA PORTORICENSIS Young.
On *Croton lucidus*, Guánica (Stevens) (103).

PHYLLOSTICTA SACCHARI Speg.
On *Saccharum officinarum*, Gurabo, Río Piedras; Juana Díaz (Stevens) (48, 103).

PHYLLOSTICTA SECHII Young.
On *Sechium edule*, Río Piedras; Mayagüez (Stevens) (103).

PHYLLOSTICTA STEVENSII Young.
On *Triumfetta semitriloba*, Coamo, Villa Alba (Stevens) (103).

PHYLLOSTICTA SUPERFICIALE Stevens.
On *passiflora sexflora*, Ponce, Monte de Oro, El Consumo, Adjuntas, Utuado, El Yunque, Jájome Alto, Maricao, Guayama (Stevens) (82).

SEPTORIA ASIATICA Urb.
On *Centella asiatica*, Vega Baja, San Sebastián (Stevens) (34).

SEPTORIA CHELIDONII Desm.
On *Argemone mexicana*, Guayama (Stevens) (34).

SEPTORIA FICI-INDICÆ Vogt.
On *Opuntia dillenii,* Guánica, Santa Isabel (Stevens) (82).
SEPTORIA GUETTARDÆ Garman.
On *Guettarda ovalifolia,* Monte Alegrillo (Stevens) (34).
SEPTORIA LANTANÆ Garman.
On *Lantana camara,* Porto Rico (Stevens) (34).
SEPHORIA LYCOPERSICI Speg.
On *Lycopersicum esculentum,* Río Piedras, Sabana Llana (90, 94).
SEPTORIA MICONIÆ Garman.
On *Miconia lævigata,* Las Marías (Stevens) (34).
Miconia impetiolaris, Río Piedras, Sabana Llana (90, 94).
SEPTORIA MIKANIÆ Wint.
On *Mikania* sp., El Gigante (Stevens) (82).
SEPTORIA PETITIÆ Garman.
On *Petitia domingensis,* Río Piedras; Cabo Rojo (Stevens) (34).
SEPTORIA PETROSELINI var. APII Br. & Cav.
On *Apium graveolens,* Maricao, El Gigante, Aibonito (Stevens) (82).
SEPTORIA PITYROGRAMMÆ Garman.
On *Pityrogramma calomelanos,* Maricao (Stevens) (34).
SEPTORIA ROSÆ Desm.
On *Rosa* sp., Aibonito.
VERMICULARIA ATRICHA E. & E.
On *Petiveria alliacea,* Caguas (Millspaugh). Described in Plantæ Utowanæ, pub. 43, Field Columbian Museum, Bot. Ser., vol. 2, no. 1.
VERMICULARIA GRAMINICOLA West.
On dead cane stalk, Río Piedras (48).

ZYTHIACEÆ.

ASCHERSONIA ALEYRODIS Webber.
On *Aleyrodicus minimus,* the white fly of *Psidium guajava,* Río Piedras, Caguas, Bayamón, Espinosa; Utuado, Mayagüez, Jayuya (Stevens) (46, 82).
ASCHERSONIA FLAVO-CITRINA P. Henn.
On *Aleyrodicus minimus,* Río Piedras, Martín Peña (46).
ASCHERSONIA CUBENSIS B. & C.
On scale insects on *Citrus* spp., Pueblo Viejo, Espinosa, Bayamón; on *Palicourea crocea,* Río Piedras; on *Zamia integrifolia* (Stevens) (82, 89, 96).

ASHERSONIA TURBINATA Beck.

On scale insects. Río Piedras, Vega Baja, Espinosa, Dorado, Pueblo Viejo, Coamo Springs. Host insects occur on a wide range of trees and shrubs, including *Citrus* spp., *Psidium, Casearia, Zamia, Eugenia, Erythrina,* etc. (46, 89, 96).

ZYTHIA PHASEOLI Stevens. In mss.

On *Phaseolus adenanthus*, Porto Rico (Stevens).

LEPTOSTROMATACEÆ.

LEPTOTHYRIUM POMI (M. & F.) Sacc.

On *Citrus sinensis*, Bayamón. Found in sterile condition only (89, 96).

MELASMIA COCCOLOBIÆ Stevens.

On *Coccolobis* sp., Maricao (Stevens) (82).

MELASMIA INGÆ Stevens.

On *Inga laurina*, Las Marías (Stevens) (82).

EXCIPULACEÆ.

EPHELIS MEXICANA Fr.

See *Balansia hypoxylon*.

MELANCONIACEÆ.

COLLETOTRICHUM COFFEANUM Noack.

On *Coffea arabica*. Reported by Cook in Tropical Plant Diseases, p. 166 (98).

COLLETOTRICHUM CRADWICKII Bancroft.

On *Theobroma cacao*, Mayagüez (Fawcett) (27).

COLLETOTRICHUM CURVISETUM Stevens.

On *Hura crepitans*. Canóvanas; Añasco, Mayagüez (Stevens) (82).

COLLETOTRICHUM ERYTHRINÆ E. & E.

On *Pithecolobium unguis-cati*. Cerro, Boquerón, Guánica, Guanajibo, Mona, Desecheo (Stevens) (82).

COLLETOTRICHUM FALCATUM Went.

On *Saccharum officinarum*. Río Piedras, Fajardo, Yauco, Canóvanas, Yabucoa, Carolina, Las Monjas, Ponce, Fortuna. For the most part on dead and dying leaves and stalks, but occasionally as a wound parasite of the stalk. (38, 40, 48, 91, 94, 105).

Colletotrichum glœosporioides Penz.

On *Citrus* spp., Río Piedras, Pueblo Viejo, Espinosa, Manatí, Bayamón, Sabana Llana, Vega Baja, Santana. Causing leaf spot, fruit spot and rot, tear staining of fruit, and withertip of terminal branches and twigs (15, 23, 26, 89, 94, 96, 98).

Mangifera indica, Río Piedras (23, 89, 94).

Colletotrichum Higginsianum Sacc.

On *Brassica rapæ*, Río Piedras.

Colletotrichum lagenarium (Pers.) E. & H.

On *Cucumis sativus*, Río Piedras.

Cucurbita melo, Río Piedras (90).

Colletotrichum lindemuthianum (Sacc & Magn.) Scrib.

On *Phaseolus vulgaris*, Río Piedras (90, 94).

Colletotrichum lineola Cda.

On *Holcus halepense*, Sabana Llana.

Holcus sorghum, Trujillo Alto (94).

Colletotrichum lobeliæ Stevens.

On *Lobelia assurgens* var. *Portoricensis*, Maricao (Stevens) (82).

Colletotrichum nigrum E. & H.

On *Capsicum annuum*, Río Piedras. Causing a rot of the fruit (90).

Colletotrichum omnivorum Hals.

On *Pandanus* sp., Sabana Llana, Río Piedras; Caguas (Stevens) (82).

Colletotrichum philodendri P. Henn.

On *Philodendron krebsii*, Arecibo, Lares (Stevens) (82).

Colletotrichum phomoides (Sacc.) Ches.

On *Lycopersicum esculentum*, Río Piedras (90, 94).

Colletotrichum piperis Stevens.

On *Piper umbellatum*, Río Piedras; Caguas (Stevens) (82).

Glœosporium hemerocallidis E. & E.

On *Hymenocallis expansa*, Bayamón.

Glœosporium manihot Earle.

On *Manihot utilissima*, Río Piedras.

Producing a die-back of terminal twigs (90).

Glœosporium melongenæ E. & H.

On *Solanum melongena*, Río Piedras (36, 90).

Glœosporium musarum Cke. & Mass.

On *Musa paradisiaca*, Río Piedras. Common in all parts of the Island.

GLŒOSPORIUM PIPERATUM E. & E.
On *Capsicum annuum*, Río Piedras (90, 94).
Capsicum frutescens, Pueblo Viejo.

GLŒOSPORIUM PSIDII G. Del.
See *Glomerella cingulata*.

GLŒOSPORIUM RUFOMACULANS (Berk.) Thüm.
See *Glomerella cingulata*.

GLŒOSPORIUM VANILLÆ Cke.
See *Glomerella cingulata*.

GLŒOSPORIUM VIOLÆ B. & Br.
On *Viola* sp., Mayagüez (Stevens) (82).

MELANCONIUM SACCHARI Mass.
On dead and dying sugar-cane stalks and leaf sheaths. Yabucoa, Río Piedras, Fortuna, Aguadilla, Fajardo, Canóvanas, Carolina, Juncos, Arecibo, Barceloneta, Caguas, Quebradillas, Utuado, Isabela, Añasco, Guánica, Vega Baja, Bayamón, Toa Baja (15, 22, 23, 38, 40, 41, 44, 47, 48, 91, 94, 105).

MELANCONIUM SACCHARINUM (?) Penz. & Sacc.
On *Bambusa vulgaris*, Trujillo Alto.
Cymbopogon citratus, Río Piedras.
Saccharum officinarum, Río Piedras, Mercedita, Fajardo (41, 44, 48, 105).

PESTALOZZIA COCCOLOBÆ E. & E.
On *Coccolobis uvifera*, Boquerón (Stevens) (82).

PESTALOZZIA FUNERA Desm.
On *Acrista monticola*, El Yunque (Stevens).
Chrysobalanus icaco, Santurce (Stevens).
Clusia rosea, Maricao (Stevens).
Hippocratea volubilis, Río Piedras.
Inga vera, Maricao (Stevens).
Musa paradisiaca, Rosario, Barros (Stevens).
Pithecolobium unguis-cati, Mona (Stevens).
Poinciana pulcherrima, Río Piedras; Mayagüez (Stevens) (82).

PESTALOZZIA GUEPINIA Desm.
On *Citrus* spp., Espinosa, Río Piedras (96).
Jambosa jambos, Pueblo Viejo.
Mangifera indica, Trujillo Alto, Río Piedras (94).

PESTALOZZIA PALMARUM Cke.

On *Acrocomia media*, Río Piedras, Espinosa.

Areca catechu, Río Piedras.

Cocos nucifera, Río Piedras, Santurce (39).

Phœnix reclinata, Aibonito (94).

MONILIACEÆ.

ACROSTALAGMUS ALBUS Pr.

On *Aphis* sp., on *Hibiscus esculentus*, *Cucumis sativus*, *Solanum melongena*, *Capsicum annuum*, *Palicourea* sp., *Eupatorium odoratum*, Río Piedras, Carolina, Comerío.

Corythaica monacha, on *Solanum melongena*, Río Piedras.

Sipha flava, on *Saccharum officinarum*, Río Piedras (46, 89).

ARTHROBOTRYS SUPERBA Cda.

On dead and dying sugar-cane leaves and on cane debris, Río Piedras, Gurabo (48).

ASPERGILLUS FLAVUS Link.

On *Pseudococcus sacchari*, Río Piedras, Patillas, Fajardo, Carolina, Guánica. A strain morphologically not distinguishable is common as a mold of tobacco, cloth, culture media, and other dead plant material. Also isolated from soil (46, 48, 96).

ASPERGILLUS NIGER Van Tiegh.

Isolated from soil. Also occurs occasionally as a citrus fruit rot, and on plant material in damp chambers (48, 96).

ASPERGILLUS ROSEUS Link.

Isolated from soil, Río Piedras.

ASPERGILLUS TERREUS Thom.

On musty tobacco, Porto Rico. Described by Thom in Amer. Jour. of Bot., v. 5, no. 2, Feb. 1918, pp. 85–90, including mention of its occurrence in Porto Rico.

BLASTOTRICHUM MICONIÆ Stevens.

On *Miconia lævigata*, Maricao, Utuado, Aguas Buenas (Stevens) (82).

BOTRYTIS RILEYI Farl.

On *Laphygma frugiperda*, Río Piedras, Guánica (46).

CEPHALOSPORIUM LECANII Zimm.

On *Aspidiotus destructor*, on *Cocos nucifera*, Punta Cangrejos.

Coccus mangifera, on *Mangifera indica*, Río Piedras.

Pseudococcus nipæ, on *Psidium guayaba*, and *Erythrina glauca*, Río Piedras.

CEPHALOSPORIUM LECANII Zimm.—*Continued.*

On *Saissetia hemispherica* on a wide range of trees and shrubs, Río Piedras, Espinosa, Bayamón, Vega Baja, Comerío, Sabana Llana (46, 96).

DIPLOSPORIUM ALBUM Bon. var. *fungicolum* Stevens.

On *Parodiella cayaponiæ* on *Cayaponia* sp., Utuado (Stevens) (82).

METARRHIZIUM ANISOPLIÆ (Metsch.) Sor.

On *Aphodius* sp., *Canthon* sp., *Dsycinctus barbatus, Ligyrus tumulosus, Metamasius hemipterus, Phyllophaga* spp., *Phytalus insularis, Strategus titanus*, and a number of undetermined Scarabæids, an earwig, and a roach, Río Piedras, Guánica, Fajardo, Santa Isabel, Sierra de Naguabo, Añasco (46, 78, 84, 105).

MONILIA SITOPHILA (Mont.) Sacc.

On dead sugar-cane debris after burning, Río Piedras. Common in all parts of the Island. Also observed at base of plants of *Gynerium sagitatum* and *Sabal causiarum* injured by fire (48).

MONOGRAMMIA MICONIÆ Stevens.

On *Miconia* sp., Yabucoa (Stevens) (82).

MONOSPORIUM UREDINICOLUM Stevens.

On *Coleosporium ipomœæ* on *Ipomœa batatas* (Stevens) (82).

OIDIUM LACTIS Fres.

Causing acetic fermentation of fruit juices, Río Piedras.

PELLICULARIA KOLEROGA Cooke.[1]

On *Coffea arabica*, Moca, Mayagüez. Also reported by Fawcett on *C. arabica* var. *columnaris, C. abeokuta, C. laurentii, C. stenophylla*. This species is treated extensively in a number of publications (15, 23, 24, 28, 30, 31, 81, 82).

PENICILLIUM CRUSTACEUM L.

On dead plant material, Río Piedras (96).

PENICILLIUM DIGITATUM (Fr.) Sacc.

On fruit of *Citrus sinensis, C. decumana*, and *C. limonis*. Common in all citrus districts of the Island (58, 84, 89, 94, 96).

PENICILLIUM DIVARICATUM Thom.

Isolated from soil, Río Piedras.

PENICILLIUM ITALICUM Wehmer.

On fruit of *Citrus* spp. Not common (89, 96).

[1] See *Corticium koleroga*.

Penicillium lilacinum Thom.
Isolated from soil, Río Piedras.

Penicillium luteum Zukal.
Isolated from soil, Río Piedras.

Piricularia grisea (Cke.) Sacc.
(*Piricularia oryzæ* Cav.)
On *Oryza sativa*, Mayagüez (Thomas).
Syntherisma digitata, Río Piedras.

Ramularia areola Atkin.
On *Gossypium barbadense* (20).

Ramularia coleosporiæ Sacc.
On *Coleosporium ipomœæ* on *Ipomœa batatas* (6).

Ramularia cylindrosporioides Stevens. In mss.
On *Piper medium*, Porto Rico (Stevens).

Spicaria colorans.
On *Theobroma cacao*, Fawcett (30).

Sporotrichum globuliferum Speg.
On *insects* (thrips, Drosophilid. leaf hoppers), Río Piedras, Bayamón, Espinosa (94).

Trichoderma lignorum (Tode) Harz.
On dead and dying sugar-cane leaves, leaf-sheaths, and stalks. Río Piedras, Cambalache, Naguabo. Common everywhere (48, 94).

Trichothecium fusarioides Stevens.
On *Phyllachora peribebuyensis* on *Miconia* sp., Maricao (Stevens) (82).

Verticillium heterocladum Penz.
On insects (undet.), on *Ocotea leucoxylon* and *Nectandra* sp., Río Piedras (46).

DEMATIACEÆ.

Alternaria dianthi S. & H.
On *Dianthus* sp., San Juan (94).

Alternaria citri Pierce.
On *Citrus sinensis* (fruit), Pueblo Viejo, Bayamón, Río Piedras (84, 89, 96).

Alternaria solani (E. & M.) J. & G.
On *Datura suaveolens*, Barros, Coamo, Aguas Buenas (Stevens) (82).
Solanum tuberosum, Río Piedras.

ARTHRINIUM SACCHARICOLA Stevenson.
On dead sugar-cane leaves, Río Piedras (48).

BASISPORIUM GALLARUM Moll.
On dead stalks and leaves of sugar-cane and other grasses, Juncos, Río Piedras (48).

BRACHYSPORIUM STEMPHYLIODES (Cd.) Sacc.
On *Anona montana*, Mayagüez (Stevens) (82).

CERCOSPORA ACHYRANTHES Syd.
On *Achyranthes aspera*, Guánica, Hormigueros, Bayamón (Stevens) (82).

CERCOSPORA ACROCOMIÆ Stevenson.
On *Acrocomia media*, Río Piedras, Espinosa (94).

CERCOSPORA ALTERNANTHERÆ E. & L.
On *Alternanthera portoricensis*, Yauco, Coamo (Stevens) (82).

CERCOSPORA AMARYLLIDIS Ell. & Ev.
On *Hymenocallis expansa*, Punta Cangrejos; Santurce, Caomo (Stevens) (104).

CERCOSPORA ATRICINCTA H. & W.
On *Crassina elegans*, Espinosa, Río Piedras (89).

CERCOSPORA BERNARDIÆ Stevens.
On *Bernardia bernardia*, Guánica (Stevens) (82).

CERCOSPORA BETICOLA Sacc.
On *Beta vulgaris* in var., Pueblo Viejo, Río Piedras (90, 94).

CERCOSPORA BIFORMIS Petch.
On *Passiflora sexflora*, Mayagüez (Stevens) (82).

CERCOSPORA BIXÆ A. & N.
On *Bixa orellana*, Mayagüez, Lares, Rosario (Stevens) (82).

CERCOSPORA BLOXAMI Berk. & Br.
On *Brassica arvensis*, Río Piedras.
Brassica integrifolia, Río Piedras.
Brassica japonica, Barranquitas.
Brassica juncea, Río Piedras (94).
Brassica Pe-tsai, Río Piedras.
Brassica rapa, Quebradillas, Bayamón (Stevens) (90, 104).

CERCOSPORA BORINQUENSIS Young.
On *Calapogonium orthocarpum*, Río Piedras, Mayagüez (Stevens) (104).

CERCOSPORA BRADBURYÆ Young.
On *Bradburya pubescens*, Río Piedras; Mayagüez, El Yunque, Dos Bocas, San Germán, Guayama, Jayuya, Hormigueros, Cabo Rojo, Rosario (Stevens) (104).

CERCOSPORA CAJANI P. Henn.

On *Cajanus indicus*, Río Piedras; Aguas Buenas, Aguada, Maricao, Añasco, Dos Bocas, Guayanilla, El Yunque, Hormigueros, Monte de Oro (Stevens) (90, 104).

CERCOSPORA CANESCENS Ell. & Mart.

On *Dolichos lablab*, Río Piedras.

Phaseolus lunatus, Río Piedras.

Phaseolus vulgaris, Río Piedras; Guayanilla (Stevens) (60, 90).

Vigna unguiculata, Garrochales.

CERCOSPORA CAPSICI H. & W.

On *Capsicum annuum*, Río Piedras, Pueblo Viejo, Trujillo Alto (90, 94).

CERCOSPORA CARBONACEA Miles.

On *Dioscorea alata*, Vega Alta, Cabo Rojo, Vega Baja, Añasco (Stevens) (60, 61).

CERCOSPORA CASEARIÆ Stevens.

On *Casearia guianensis*, Río Piedras; Rosario, Corozal, Mayagüez (Stevens).

Casearia ramiflora, Villa Alba, Caguas, El Yunque, Quebradillas, Utuado, San Germán, Cataño, Martín Peña, Mayagüez, Aguada, Aguadilla, Maricao, Vega Baja, Bayamón, Naguabo, Jayuya (Stevens).

Casearia sylvestris, Río Piedras, Martín Peña, Sabana Llana; Mayagüez, Coamo, Río Tanamá, Hormigueros, Lajas, Corozal, Quebradillas, Ponce, Monte de Oro, El Yunque (Stevens) (82).

CERCOSPORA CASSAVÆ E. & E.

On *Manihot utilissima*, Dos Bocas (Stevens) (104). Probably the same as *C. Henningsii*.

CERCOSPORA CHAMÆCRISTÆ E. & Keller.

On *Cassia alata*, Dos Bocas, Santurce, Añasco, Mayagüez (Stevens) (104).

Cassia occidentalis, Camuy, Espinosa.

CERCOSPORA CITRULLINA Cke.

On *Citrullus vulgaris*, Punta Cangrejos, Río Piedras, Pueblo Viejo (36, 84, 90).

CERCOSPORA COFFEICOLA B. & C.

(*C. coffeæ* Zimm.)

On *Coffea arabica*, Espinosa, Río Piedras; Añasco, Maricao (Stevens) (27, 31, 60).

CERCOSPORA CONSPICUA Earle.
On *Cleome spinosa*, Comerío; Mayagüez (Stevens) (21, 104).

CERCOSPORA CRUENTA Sacc.
On *Phaseolus lunatus*. Coll. N. Y. Bot. Garden.
Vigna unguiculata, Río Piedras (90, 94).

CERCOSPORA CUCURBITÆ E. & E.
On *Lagenaria leucantha*, Río Piedras (90).

CERCOSPORA CUCURBITICOLA P. Henn.
On *Cayaponia* spp., Maricao, Rosario (Stevens) (82).

CERCOSPORA DENSISSIMA Speg.
On *Sida* sp., Mona Island (Stevens) (104).

CERCOSPORA FLAGELLARIS E. & M.
On *Phytolacca icosandra*, Maricao (Stevens) (82).

CERCOSPORA GILBERTII Speg.
On *Iresine panniculata*, El Alto de la Bandera (Stevens) (82).

CERCOSPORA GOSSYPINA Cke.
On *Gossypium barbadense*, Carolina.

CERCOSPORA GUANICENSIS Young.
On *Guilandina crista*, Guánica (Stevens) (104).

CERCOSPORA HENNINGSII Allesch.
On *Manihot utilissima*, Bayamón, Moca, Pueblo Viejo, Martín Peña; Hormigueros (Stevens) (60, 90, 94).

CERCOSPORA HIBISCI T. & Earle.
On *Hibiscus esculentus*, Río Piedras; Quebradillas, Aguadilla, Cabo Rojo (Stevens) (60, 90, 94).
Hibiscus tiliaceus, Camuy; Rosario, Dos Bocas, Las Marías, Maricao (Stevens) (104).

CERCOSPORA HURÆ Stevens.
On *Hura crepitans*, Mayagüez, Añasco (Stevens) (82).

CERCOSPORA HYDROPIPERIS (Thüm.) Speg.
On *Persicaria punctata*, Río Piedras, Mayagüez; Utuado, Coamo, Corozal, Ciales (Stevens) (104).

CERCOSPORA LACTUCÆ Stevenson.
On *Lactuca sativa*, Río Piedras (90, 94).

CERCOSPORA LEPIDII Peck.
On *Lepidium virginicum*, Espinosa; Mona Island (Stevens) (104).

CERCOSPORA LONGIPES Butler.
On *Saccharum officinarum*, Río Piedras (48, 105).

CERCOSPORA MALACHRÆ Heald & Wolf.
(*Cercospora malachræ* Young).
On *Malachra rotundifolia*, Río Piedras; San Sebastián, Ponce, Yauco, Guánica, San Germán, Vega Baja (Stevens) (104).

CERCOSPORA MARICAOENSIS Young.
On *Teramnus uncinatus*, Maricao, Dos Bocas, Cabo Rojo (Stevens) (104).

CERCOSPORA MIKANIACOLA Stevens.
On *Mikania* sp., Utuado, Aguada, Maricao (Stevens) (82).

CERCOSPORA MUCUNÆ Syd.
On *Mucuna pruriens*, Utuado, Dos Bocas, Mayagüez, Añasco, Rosario, Monte Alegrillo (Stevens) (104).
Stizolobium aterrimum, Río Piedras.
Stizolobium sp., Río Piedras, Espinosa, Vega Baja.

CERCOSPORA NICOTIANÆ E. & E.
On *Nicotiana tabacum*, Mayagüez, Bayamón, Espinosa, Sabana Llana; Quebradillas, Caguas, Ciales, Dos Bocas (Stevens) (60, 94).

CERCOSPORA ORYZÆ Miy.
On *Oryza sativa* Río Piedras, Canóvanas.

CERCOSPORA PERSONATA (B. & C.) E.
On *Arachis hypogea*, Río Piedras, Pueblo Viejo (15, 20, 90, 94).

CERCOSPORA PISA-SATIVÆ Stevenson.
On *Pisum sativum*, Río Piedras (90).

CERCOSPORA PHYLLITIDIS Hume.
On *Polypodium* sp., Barros (Stevens) (104).

CERCOSPORA PORTORICENSIS Earle.
On *Piper aduncum*, Río Piedras, Camuy; Mayagüez (Heller; Peñuelas, Juana Díaz, Coamo, Añasco, Ciales, Corozal, Adjuntas, Jájome Alto, Coamo Springs, Arecibo (Stevens) 19, 82).
Piper hispidum, Bayamón; Maricao, Rosario (Stevens) (104).
Piper peltatum, Río Piedras;
Piper umbellatum, Maricao, Arecibo (Stevens) (82).
Piper sp., Río Piedras, Martín Peña, Palo Seco.

CERCOSPORA RICINELLA Sacc. & Berl.
On *Ricinus communis*, Palo Seco, Naguabo, Espinosa; Jayuya, Yauco, Peñuelas, Utuado, Coamo (Stevens) (82, 94).

CERCOSPORA RIGOSPORA Atks.

On *Solanum nigrum*, Río Piedras.

CERCOSPORA ROSICOLA (Pass.) Sacc.

On *Rosa*, spp., Garrochales, Espinosa, Arecibo, Río Piedras; Maricao (Stevens) (89, 94, 104).

CERCOSPORA SECHII Stevenson. (In ed.)

On *Sechium edule*, Río Piedras, Barceloneta (36, 90).

CERCOSPORA SESAMI Zimm.

On *Sesamum orientale*, Garrochales, Río Piedras (90).

CERCOSPORA SIMULATA E. & E.

On *Cassia alata*. Coll. N. Y. Bot. Garden. Probably the same as *C. chamaecristae*.

CERCOSPORA STEVENSII Young.

On *Andira jamaicensis*, Dos Bocas (Stevens) (104).

CERCOSPORA THOUINIAE Stevens.

On *Thouinia striata*, Maricao (Stevens) (82).

CERCOSPORA TRICHOPHILA Stevens.

On *Helicteres jamaicensis*, Peñuelas (Stevens).

Solanum torvum, Mayagüez, Utuado, Vega Baja, Río Tanamá, Monacillo, Manatí, Mona Island (Stevens).

Solanum verbascifolium, Río Piedras; El Gigante, El Alto de la Bandera (Stevens) (82).

CERCOSPORA TRICHOSTIGMAE Stevens.

On *Trichostigma octandra*, Barceloneta, Río Piedras (Stevens) (82).

CERCOSPORA VAGINAE Kruger.

On *Saccharum officinarum*, Cambalache, Arecibo, Fajardo, Río Piedras, Los Caños (38, 48, 94, 105).

CERCOSPORA VIGNAE Racib.

On *Vigna unguiculata*, Río Piedras (84, 90).

CERCOSPORA VIOLAE Sacc.

On *Viola* sp., Campo Alegre, Río Piedras, Vega Baja (89).

CERCOSPORIDIUM HELLERI Earle.

On *Sphenoclea zeylanica*, Canóvanas; Mayagüez (Stevens) (19, 82).

CERCOSPORIUM BETICOLA (?).

On "beans" as a root rot. P. R. Agri. Exp. Sta. Report 1903. Given by Cook (Dis. of Tropical Plants, p. 230) as *C. urticola*.

CLADOSPORIUM CALOTROPIDIS Stevens.

On *Calotropis procera*, Guayanilla (Stevens) (82).

CLADOSPORIUM (?) CITRI Mass.

On *Citrus aurantium*, Trujillo Alto, Sabana Llana, Naguabo, Bayamón.

Citrus decumana, Río Piedras, Palo Seco, Sabana Llana, Bayamón, Vega Baja, Espinosa, Manatí, Barceloneta, Garrochales, Santana, Naguabo, Mayagüez, Pueblo Viejo.

Citrus limonia, Bayamón, Pueblo Viejo, Palo Seco, Sabana Llana.

Citrus nobilis, Bayamón.

Citrus sinensis, Trujillo Alto, Bayamón.

An extended bibliography (6, 8, 15, 20, 22, 23, 27, 84, 88, 89, 93, 94, 96, 99).

CLADOSPORIUM FULVUM Cke.

On *Lycopersicum esculentum*, Río Piedras; Cabo Rojo, Utuado, Florida, Caguas (Stevens) (36, 82, 90, 94).

Solanum torvum, Río Piedras.

CLADOSPORIUM GUANICENSIS Stevens.

On *Argemone mexicana*, Palo Seco; Guánica, Coamo (Stevens) (82).

CLADOSPORIUM HERBARUM Link.

On *Canna* sp., Río Piedras; Mayagüez, Aibonito (Stevens).

Canna coccinia, Villa Alba (Stevens).

Canna glauca, Utuado (Stevens).

Canavalia obtusifolia, Boquerón (Stevens) (82).

Dead and dying flowers, leaves and stems of *Zea Mays*, *Sesbania grandiflora*, *Bauhinia* sp., *Saccharum officinarum*, *Solanum melongena*, Bayamón, Río Piedras, Trujillo Alto (48, 96).

CLADOSPORIUM HYPOPHLOEM B. & C.

On *Thouinia* sp. Coll. N. Y. Bot. Garden (Heller).

CLADOSPORIUM MANSONI Cast. and Chalmers.

As a cause of a human skin disease, black ringworm (49).

CLADOSPORIUM MIKANIÆ Stevens.

On *Mikania* sp., Las Marías (Stevens) (82).

ELLISIELLA PORTORICENSIS Stevens.

On *Clusia rosea*, Arecibo, Desecheo, Lajas, Hormigueros (Stevens) (82).

HAPLOGRAPHIUM ECHINATUM (Riv.) Sacc.

Isolated from soil, Río Piedras.

HAPLOGRAPHIUM PORTORICENSE Stevens. In mss.

On *Canna coccinia*, Porto Rico (Stevens).

HELMINTHOSPORIUM CALADII Stevens.
On *Caladium bicolor*, Guaynabo, Río Piedras; Mayagüez, Manatí, Añasco (Stevens) (82).

HELMINTHOSPORIUM GLABROIDES Stevens.
On *Perisporium portoricense* on *Calophyllum calaba* (Stevens) (82).

HELMINTHOSPORIUM MAYAGUEZENSE Miles.
On *Paspalum conjugatum*, Río Piedras; Mayagüez, Dos Bocas, San Germán, Añasco, Maricao (Stevens) (60, 61).

HELMINTHOSPORIUM RAVENELII Berk & Curt.
On *Sporobolus indicus*, Río Piedras; Jájome Alto, El Alto de la Bandera (Stevens) (82).

HELMINTHOSPORIUM SACCHARI Butler.
On *Saccharum officinarum*, Río Piedras, Camuy, Cambalache, Quebradillas, Barceloneta (48, 94, 105).

HELMINTHOSPORIUM SECHICOLA Stevenson. (In ed.)
On *Sechium edule*, Camuy (90).

HELMINTHOSPORIUM SPICULIFERUM E. & E.
On *Thrinax* sp., Utuado (Stevens) (82).

HELMINTHOSPORIUM STAHLII Stevens.
On *Passiflora fœtida*, Mayagüez, Luquillo, Naguabo (Stevens) (82).

HELMINTHOSPORIUM TURCINUM Pass.
On *Zea mays*, Mayagüez, Río Piedras (94).

HELMINTHOSPORIUM VARRONIÆ Stevens.
On *Varronia* sp., Florida (Stevens) (82).

HORMIACTELLA SACCHARI Johnston.
On dead leaves of sugar cane and other grasses, Río Piedras, Naguabo, Ponce, Yauco, Canóvanas, Mameyes, Añasco (48).

MACROSPORIUM PORRI Ell.
On *Allium cepa*, San Juan, Río Piedras.

MICROCLAVA COCCOLOBIÆ Stevens.
On *Coccoloba diversifolia*, Maricao (Stevens) (82).

MICROCLAVA MICONIÆ Stevens.
On *Miconia lævigata*, Aguas Buenas (Stevens) (82).

NAPICLADIUM FUMAGO Speg.
On *Miconia* sp., Arecibo (Stevens) (82).

PASSALORA CECROPIÆ Stevens.
On *Cecropia peltata*, Arecibo (Stevens) (82).

PERICONIA PYCNOSPORA Fres.

On *Xanthosoma* sp. (*Yautía*). Reported from Mayagüez (7, 8, 15, 90).

PERICONIA SACCHARI Johnston.

On dead and dying sugar-cane leaves, Río Piedras, Fajardo (48).

SEPTONEMA SACCHARI Johnston & Stevenson.

On dead sugar-cane leaves and stalks, Río Piedras (48).

TETRACOCCOSPORIS SACCHARI Stevenson.

On sugar-cane debris, Río Piedras (48).

TETRAPLOA ARISTATA B. & Br.

On dead sugar-cane stalks and leaves, Río Piedras (48).

THIELAVIOPSIS PARADOXA (De Seynes) V. Hohn.

On *Ananas sativus*, causing a fruit rot occurring in all sections of the Island (94).

Cocos nucifera, causing a trunk-bleeding disease (Fawcett, 26).

Saccharum officinarum, Río Piedras, Yabucoa, Canóvanas, Fajardo, Arecibo (23, 26, 38, 40, 41, 44, 48, 87, 91, 94, 105).

TRIPOSPORIUM STELLIGERUM Speg.

On *Anona montana*, Mayagüez (Stevens).

Chiococca alba, Vega Baja (Stevens).

Myrcia deflexa, El Alto de la Bandera (Stevens).

Rudolphia volubilis, Maricao, El Yunque (Stevens).

Winterana canella, Guayanilla (Stevens).

Zamia integrifolia (Stevens) (82).

VERTICICLADIUM GRAMINICOLUM Johnston & Stevenson.

On dead cane leaves, Río Piedras (48).

ZYGOSPORIUM OSCHIOIDES Mont.

On *Pucciniopsis carica* on *Carica papaya*, Río Piedras (60, 94).

STILBACEÆ.

DENDROGRAPHIUM ATRATUM Massee.

On dead wood, Mameyes.

GIBELLULA ARACHNOPHILA Sacc.

On spiders of the family *Attida*, Río Piedras, Vega Baja, Espinosa (46).

GRAPHIUM SACCHARI Speg.

On dead sugar-cane stalks, Río Piedras, Gurabo (48).

GRAPHIUM SQUARROSUM Ell. & Langl.

On dead bamboo, Río Piedras.

ISARIA BARBERI Giard.

(*Cordyceps Barberi* Giard.)

On larvæ of *Diatraea saccharalis*, Río Piedras, Guánica, Santa Isabel, Patillas (46).

ISARIA SAUSSUREI Cooke.

On *Bothriocera* sp., on *Palicourea crocea*, Río Piedras.

ISARIA UMBRINA Pers.

On dead wood, Río Piedras.

ISARIOPSIS GRISEOLA Sacc.

On *Phaseolus lunatus*, Río Piedras; Mayagüez (Thomas).

Phaseolus vulgaris, Río Piedras, Barceloneta, Camuy; Jayuya, Mayagüez, Dos Bocas (Stevens) (60, 90, 94).

PODOSPORIUM PALLIDA Pat.

On *Meliola amphitricha* on *Randia aculeata*. Coll. N. Y. Bot. Garden.

STILBELLA FLAVIDA Lind.

(*Stilbum flavidum* Cooke.)

On *Bryophyllum pinnatum*, Maricao (Stevens).

Citrus sinensis, *Cissus sicyoides*, *Commelina* sp., *Inga vera*, *Mangifera indica* (Fawcett) (31).

Coffea arabica, Mayagüez; Dos Bocas, Jayuya, Ponce, Monte de Oro, Maricao, El Gigante, Arecibo-Lares (Stevens). Frequently reported by Fawcett and others (6, 8, 15, 20, 23, 24, 26, 30, 31, 81, 82). Also noted by T. C. McClelland on *C. excelsa*, *C. macrocarpa*, *C. perrieri*, *C. robusta*, *C.* sp. var. *Quillou*; and by Fawcett on *C. stenophylla*, *C. arabica* var. *Columnaris*, *C. laurentii* (30).

Elephantopus mollis, Jayuya, Monte de Oro (Stevens).

Piper macrophyllum, Monte de Oro (Stevens).

Psychotria uliginosa, El Alto de la Bandera (Stevens).

Synedrella nodiflora, Ponce (Stevens) (82).

TUBERCULARIACEÆ.

AEGERITA WEBBERI Faw.

On *Aleyrodicus minimus* on *Psidium guayaba*, Río Piedras, Espinosa (46).

EPICOCCUM NEGLECTUM Desm.

On *Cestrum* sp., Cabo Rojo (Stevens) (82).

FUSARIUM CUBENSIS Er. Sm.

On *Musa paradisiaca*, Isabela, Mayagüez, Río Piedras, Moca. Causing a serious trunk rot (10, 11, 32).

FUSARIUM LIMONIS Bri.

On *Citrus decumana* (*C. limonis* root), Espinosa, Garrochales, Bayamón, Pueblo Viejo, Sabana Llana (94, 96).

FUSARIUM RADICICOLA Wollenw.

On *Musa sapientum*. Mentioned by Pratt in Jour. Agri. Research, v. 3, no. 9, p. 299, in connection with a study of the fungus on other hosts.

FUSARIUM SOLANI (Mart.) Sacc.

On *Vanilla planifolia*, Mayagüez (Thomas).

ILLOSPORIUM COMMELINÆ Stevens.

On *Commelina longicaulis*, Caguas, Rosario, Las Marías, Guayanilla, Hormigueros (Stevens).

Commelina virginica, Aguada, El Gigante (Stevens) (82).

MICROCERA FUJIKUROI Miy. & Saw.

On *Chrysomphalus aonidium* on *Citrus decumana*, Pueblo Viejo.

Lepidosaphes beckii on *Citrus decumana*, and *C. sinensis*, Bayamón, Mayagüez, Pueblo Viejo.

Pseudoanidia articulatus, on *Citrus decumana*, Pueblo Viejo (85, 89).

MYROTHECIUM VERRUCARIA (A. & S.) Dtm.

On dead sugar-cane leaves and dead citrus twigs, Río Piedras (48, 96).

PUCCINIOPSIS CARICÆ Earle.

On *Carica papaya*, Río Piedras; Guánica, Vega Baja, Mona (Stevens) (20, 60, 94).

SPEGAZZINIA ORNATA Sacc.

On dead sugar-cane leaves and other plant debris, Río Piedras, Ponce, Santa Isabel, Cortada, Sabana Llana (48).

TUBERCULARIA COCCICOLA Stevenson.

On *Lepidosaphes beckii* and *Chionaspis citri*, on *Citrus decumana* and *C. sinensis*, Espinosa, Río Piedras, Pueblo Viejo, Bayamón (94, 96).

TUBERCULARIA SACCHARICOLA Speg.

On dead sugar-cane stalks, Río Piedras, Las Monjas, Carolina (48).

STERILE MYCELIA.

HIMANTIA STELLIFERA Johnston.

On *Andropogon bicornis*, Río Piedras.

Cymbopogon citratus, Río Piedras.

Cyperus sphacelatus, Río Piedras.

Dichromena ciliata, Río Piedras.

HIMANTIA STILLIFERA Johnston.—*Continued.*

On *Heliotropium indicum*, Río Piedras.

Panicum laxum, Río Piedras.

Panicum maximum, Río Piedras.

Paspalum paniculatum, Río Piedras.

Paspalum plicatulum, Río Piedras.

Paspalum secans, Río Piedras.

Paspalum millegrana, Río Piedras.

Paspalum virgatum, Río Piedras.

Saccharum officinarum, Río Piedras, Cambalache, Juncos, Carolina, Guayama, Camuy, Isabela, Humacao, Peñuelas (23 48, 91, 94, 105).

Rynchospora cyperoides, Río Piedras.

Sporobolus indica, Río Piedras.

Stenotaphrum secundatum, Río Piedras.

Syntherisma digitata, Río Piedras.

Zea mays, Toa Baja.

OZONIUM STUPOSUM Pers.

Reported from the Schwanecke collection (50).

RHIZOCTONIA SOLANI Kühn.

See *Corticium vagum*.

SCLEROTIUM BATATICOLA Taub.

On *Ipomaea batatas*, Río Piedras. Charcoal rot.

SCLEROTIUM GRISEUM Stevenson. (In ed.)

On *Musa paradisiaca*, Río Piedras.

Saccharum officinarum, Río Piedras, Hormigueros, Las Monjas (48).

Zea mays, Río Piedras.

SCLEROTIUM PORTORICENSE Stevens.

On *Capriola dactylon*, Río Piedras; Santurce (Stevens) (82).

SCLEROTIUM ROLFSII Sacc.

On *Artocarpus communis*, Bayamón.

Bambusa vulgaris, Río Piedras.

Capsicum annuum, Río Piedras (94).

Citrus decumana, Bayamón, Sabana Llana (94, 96).

Daucus carota, Río Piedras.

Lycopersicum esculentum, Río Piedras.

Phaseolus vulgaris, Río Piedras.

Saccharum officinarum, Río Piedras, Las Monjas, Guaynabo, Hormigueros (38, 48, 94, 105).

Solanum melongena, Río Piedras (90, 94).

SCLEROTIUM ROLFSII Sacc.—*Continued.*
On *Triticum vulgare*, Mayagüez (Thomas).
Vicia faba, Río Piedras.

FUNGI OF UNKNOWN AFFINITY.

GRAPHIOLA CONGESTA B. & Rav.
Coll. N. Y. Bot. Garden. Host unknown.
GRAPHIOLA PHŒNICIS (Moug.) Port.
On *Inodes causiarum*, Jayuya (Stevens) (82).
Phœnix dactylifera, Santa Rita, Santurce, San Juan, Palo Seco (20, 81, 82, 89, 94).
Thrinax præceps, Utuado (Stevens) (82).

PARASITIC ALGAE.

CHROOLEPIDÆ.

CEPHALEUROS VIRESCENS Kunze.
(*Cephaleuros mycoidea* Karst.)
(*Cephaleuros candelabrum* Lagerh.)
On *Achras zapota*, Río Piedras.
Acrodiclidium salicifolium, Hormigueros (Stevens).
Alchornea latifolia, Río Piedras.
Artocarpus incisa, Espinosa.
Cajanus indicus, Vega Baja, Río Piedras (37).
Camphora officinalis, Naguabo.
Casearia sp., Río Piedras.
Cestrum laurifolium, Mayagüez (Stevens) (82).
Chrysobalanus icacao, Espinosa.
Citrus aurantifolia, Río Piedras, Sabana Llana (96).
Citrus aurantium, Palo Seco, Manatí (96).
Citrus decumana, Barceloneta, Trujillo Alto, Río Piedras (89, 96).
Citrus limonia, Caguas, Campo Alegre (96).
Clusia rosea, Naguabo.
Coccolobis diversifolia, Maricao (Stevens) (82).
Cupania americana (Stevens) (82).
Cydista æquinoctialis, Río Piedras.
Dendropanax arboreum, Río Tanamá (Stevens).
Eriobotrya japonica, Naguabo.
Ficus lævigata, Río Piedras.
Ficus nitida, Río Piedras.

CEPHALEUROS VIRESCENS Kunze.—*Continued.*

On *Ficus reptans*, Bayamón.

Hibiscus rosa-sinensis, Río Piedras.

Inga laurina, Jájome Alto, Mayagüez (Stevens).

Inga vera, Río Piedras.

Jambosa jambos, Espinosa: Añasco (Stevens).

Lasiacis sorghoidea, Jájome Alto (Stevens) (82).

Lonicera japonica, Naguabo.

Mangifera indica, Río Piedras.

Meibomia axillaris, Río Piedras.

Miconia laevigata, Mayagüez (Stevens) (82).

Miconia impetiolaris, Bayamón.

Muehlenbeckia platyclada, Río Piedras.

Myrcia deflexa, Mayagüez (Stevens).

Nectandra patens (Stevens).

Ocotea leucoxylon, Mayagüez (Stevens).

Piper medium, Río Piedras.

Polyscias guilfoylei, Naguabo.

Psidium guayava, Río Piedras, Espinosa; Mayagüez (Stevens).

Somidesia lindeniana, Jájome Alto (Stevens) (82).

Theobroma cacao, Mayagüez.

Vanilla planifolia, Mayagüez (Thomas).

SUMMARY.

	Genera.	Species.
Myxomycetes	14	27
Schizomycetes	3	9
Phycomycetes	10	17
Ascomycetes:		
Saccaromycetales	1	3
Perisporiales	22	141
Hypocreales	25	34
Dothidiales	4	21
Sphæriales	38	95
Hysteriales	2	4
Pezizales	15	19
Phacidiales	1	2
Basidiomycetes:		
Ustilaginales	11	19
Uredinales	20	161
Agaricales—		
Tremellaceæ	3	8
Clavariaceæ	1	2
Thelephoraceæ	11	41
Hydnaceæ	3	9
Polyporaceæ	10	86
Agaricaceæ	22	46
Lycoperdales	9	20
Fungi Imperfecti:		
Phomatales	16	72
Melanconiales	4	31
Moniliales—		
Moniliaceæ	21	31
Dematiaceæ	24	104
Stilbaceæ	7	10
Tuberculariaceæ	9	13
Sterile mycelia, misc	6	10
Total	312	1,035

HOST INDEX.

A

Abutilon hirtum
  Puccinia heterospora
Abutilon indicum
  Puccinia heterospora
Abutilon umbellatum
  Phyllosticta hybiscina
Acacia riparia
  Ravenelia Stevensii
Acalypha bisetosa
  Meliola arecibensis
Acalypha mosaica
  Rosellinia bunodes
Achras zapota
  Cephaleuros virescens
Achyranthes aspera
  Cercospora achyranthes
Acrista monticola
  Auerswaldia palmicola
  Meliola furcata
  Pestalozzia funerea
Acrocomia media
  Cercospora acrocomiae
  Pestalozzia palmarum
Acrodiclidium salicifolium
  Cephaleuros virescens
Adiantum sp.
  Meliola pteridicola
Adiantum latifolium
  Meliola pteridicola
  Micropeltis manthae (?)
  Uredo gymnogrammes
Adiantum tenerum
  Phyllosticta adianticola
Aegiphila martinicensis
  Guignardia prominens
Aeschynomene americana
  Uredo aeschynomensis
Agave rigida var. sissalana
  Endothia Parryi
  Lembosia agaves
Ageratum conyzoides
  Puccinia rosea
Aklema petiolaris
  Puccinia euphorbiæ
Albizzia lebbeck
  Phyllosticta divergens
Alchornea latifolia
  Cephaleuros virescens
  Olivea capituliformis
Allium cepa
  Macrosporium porri
  Urocystis cepulæ
Allophylus crassinervis
  Meliola thouiniæ
Alpinia antillarum
  Heterothecium phyllocharis
  Phyllachora renalmiæ
Alternanthera portoricensis
  Cercospora alternantheræ
Alternanthera sessilis
  Guignardia cephalariæ var. alternantheræ
Amaranthus spinosus
  Albugo bliti
Amaranthus viridis
  Albugo bliti
Amomis caryophyllata
  Meliola amomicola
Amygdalus persica
  Tranzschelia punctata
Amyris elemifera
  Meliola monensis

Ananas sativus
Spegazzinia ornata
Thielaviopsis paradoxa
Andira jamaicensis
Cercospora Stevensii
Meliola andiræ
Physalospora andiræ
Andropogon bicornis
Himantia stellifera
Meliola panici
Myriogenospora Bresadoleana
Phyllachora luteo-maculata
Tolyposporella Brunkii
Andropogon brevifolius
Phyllachora graminis
Uredo venustula
Andropogon leucostachyus
Dothichlœ atramentosa
Meliola panici
Phyllachora luteo-maculata
Aneimia sp.
Meliola pteridicola
Aneimia adiantifolia
Meliola pteridicola
Anona montana
Brachysporium stemphyloides
Meliola longipoda
Triposporium stelligerum
Anthurium acaule
Mycosphærella anthurii
Anthurium scandens
Uredo anthurii
Apium graveolens
Bacillus carotovorus
Phyllosticta apii
Septoria petroselini var. apii
Arachis hypogea
Cercospora personata
Uredo arachidis
Ardisia guadalupensis
Meliola myrsinacearum
Argemone mexicana
Cladosporium guanicensis
Septoria chelidonii
Aristida portoricensis
Balansia discoidea
Dothichlœ aristidæ
Arracacia anthorrhiza
Erysiphe polygoni
Arthrostylidium sarmentosum
Dimeriopsis arthrostylidicola
Phyllachora graminis
Artocarpus camansi
Uredo artocarpi
Artocarpus insisa
Cephaleuros virescens
Sclerotium Rolfsii
Uredo artocarpi
Zignoella algaphial
Asclepias curassavica
Puccinia concrescens
Uromyces Howei
Asclepias nivea
Puccinia concrescens
Avicennia nitida
Meliola sepulta
Axonopus compressus
Myriogenospora Bresadoleana
Uredo paspalicola

B

Bambusa vulgaris
Melanconium saccharinum
Uredo paspalicola
Banisteria laurifolia
Meliola rectangularis
Bauhinia pauletia
Cladosporium herbarum
Uromyces jamaicensis
Begonia decandra
Stilbella flavida
Bernardia bernardia
Cercospora bernardiæ

- Beta vulgaris
  - Cercospora beticola
- Bidens leucantha
  - Entyloma guaraniticum
  - Sphærotheca humuli
  - Thecaphora pustulata
  - Uromyces bidenticola
  - Uromyces bidentis
- Bidens pilosa
  - Uromyces bidenticola
  - Uromyces bidentis
- Bidens reptans
  - Sphærotheca humuli
- Bihai borinquena
  - Uredo heliconiæ
- Bixa orellana
  - Cercospora bixæ
  - Phyllosticta bixina
  - Uredo bixæ
- Blechum Brownei
  - Puccinia blechi
- Bletia patula
  - Uredo nigropunctata
- Boerhaavea erecta
  - Albugo platensis
- Boerhaavea hirsuta
  - Albugo platensis
- Borreria lævis
  - Meliola psychotriæ
  - Puccinia lateritia
- Borreria ocimoides
  - Meliola psychotriæ
- Borreria verticillata
  - Puccinia lateritia
- Bradburya pubescens
  - Cercospora bradburyæ
  - Meliola bicornis
- Bradburya virginiana
  - Meliola bicornis
- Brassica arvensis
  - Cercospora bloxami
- Brassica integrifolia
  - Albugo candida
  - Cercospora bloxami
  - Erysiphe polygoni
- Brassica japonica
  - Cercospora bloxami
- Brassica juncea
  - Bacillus carotovorus
  - Cercospora bloxami
- Brassica napi
  - Cercospora bloxami
- Brassica oleracea
  - Bacterium campestris
- Brassica Pe-tsai
  - Cercospora bloxami
- Brassica rapæ
  - Cercospora bloxami
  - Colletotrichum Higginseanum
- Bromelia pinguin
  - Perisporium bromeliæ
- Bryophyllum pinnatum
  - Stilbella flavida
- Byrsonima crassifolia
  - Uredo notata
- Byrsonima lucida
  - Meliola byrsonimæ

C

- Cæsalpinia pulcherrima
  - Ravenelia Humphreyana
- Cajanus indicus
  - Cephaleuros virescens
  - Cercospora cajani
  - Creonectria grammicospora
  - Megalonectria pseudotrichia
  - Nectria episphæria
  - Pleonectria megalonectria
  - Triblidium rufulum
  - Uromyces dolicholi
- Caladium bicolor
  - Helminthosporium caladii

Calathea lutea
Puccinia cannæ
Calophyllum calaba
Meliola calophylli
Perisporium portoricense
Calopogonium orthocarpum
Cercospora borinquensis
Meliola bicornis var. calopogonii
Calotropis procera
Cladosporium calotropidis
Camphora officinalis
Cephaleuros virescens
Campyloneurum sp.
Corynelia pteridicola
Canavalia ensiformis
Cerotelium canavaliæ
Canavalia gladiata
Cerotelium canavaliæ
Cladosporium herbarum
Canavalia obtusifolia
Cladosporium herbarum
Canna coccinea
Cladosporium herbarum
Haplographium portoricense
Puccinia cannæ
Canna edulis
Periconia pycnospora
Canna glauca
Cladosporium herbarum
Puccinia cannæ
Canna indica
Myrmæcium cannæ (?)
Capriola dactylon
Puccinia cynodontis
Sclerotium portoricense
Capsicum annuum
Cercospora capsici
Cladosporium herbarum
Colletotrichum nigrum
Capsicum annuum—*Cont.*
Gloeosporium piperatum
Pestalozzia funerea
Sclerotium Rolfsii
Capsicum baccatum
Meliola capsicola
Capsicum frutescens
Gloeosporium piperatum
Cardiospermum microcarpum
Puccinia arechavelatæ
Carica papaya
Colletotrichum falcatum
Glomerella cingulata
Pucciniopsis caricæ
Zygosporium oschioides
Casearia sp.
Cephaleuros virescens
Meliola paulliniæ
Casearia aculeata
Meliola paulliniæ
Casearia arborea
Meliola paulliniæ
Casearia guianensis
Cercospora caseariæ
Casearia ramiflora
Cercospora caseariæ
Meliola paulliniæ
Casearia sylvestris
Cercospora caseariæ
Meliola paulliniæ
Cassia alata
Cercospora chamæcrista
Cercospora simulata
Cassia emarginata
Ravenelia portoricensis
Cassia fistula
Phyllachora cassiæ
Cassia occidentalis
Cercospora chamæcrista
Erysiphe polygoni

Cassia quinquangulata
Meliola toruloidea
Uredo lutea
Cassia tora
Erysiphe polygoni
Cayaponia americana
Cercospora cucurbiticola
Dimerium cayaponiæ
Uromyces Hellerianus
Cayaponia racemosa
Meliola cucurbitacearum
Uromyces Hellerianus
Cecropia peltata
Passalora cecropiæ
Cenchrus carolinianus
Puccinia cenchri
Cenchrus echinatus
Phyllachora sphærosperma
Puccinia cenchri
Cenchrus myosuroides
Phyllachora sphærosperma
Cenchrus viridis
Puccinia cenchri
Centella asiatica
Septoria asiatica
Cestrum sp.
Epicoccum neglectum
Cestrum laurifolium
Cephaleuros virescens
Meliola gesneriæ
Uromyces cestri
Cestrum macrophyllum
Meliola gesneriæ
Uromyces cestri
Chætochloa geniculata
Puccinia substriata
Chaetochloa setosa
Puccinia cameliæ
Chamæcrista aeschynomene
Erysiphe polygoni
Ravenelia cassiæcola
Chamæcrista diphylla
Erysiphe polygoni
Chamæcrista glandulosa
Meliola chamæcristæ
Ravenelia cassiæcola
Chamæcrista granulata
Meliola chamæcristicola
Chamæsyce brasiliensis
Microsphæra euphorbiæ
Uromyces proëminens
Chamæsyce hirta
Uromyces proëminens
Chamæsyce hypericifolia
Microsphæra euphorbiæ
Uromyces proëminens
Chamæsyce prostrata
Uromyces proëminens
Chiococca alba
Meliola chiococcæ
Meliola psychotriæ
Triposporium stelligerum
Chloris petræa
Dothichloe atramentosa
Meliola panici
Chrysobolanus icaco
Cephaleuros virescens
Mycosphærella chrysobalani
Pestalozzia guepinia
Chrysophyllum sp.
Meliola ocoteicola
Cissus acida
Mykosyrinx cissi
Cissus erosa
Mykosyrinx cissi
Cissus sicyoides
Endophyllum circumscriptum
Meliola Merrillii
Mykosyrinx cissi
Phyllosticta cissicola
Stilbella flavida

Citrullis vulgaris
  Cercospora citrullina
  Diplodia sp.
Citrus aurantifolia
  Cephaleuros virescens
  Diplodia natalensis
  Penicillium digitatum
Citrus aurantium
  Cephaleuros virescens
  Cladosporium citri
  Stereum coffearum
Citrus decumana
  Aspergillus flavus
  Aspergillus niger
  Capnodium citri
  Cephaleuros virescens
  Cladosporium citri
  Cladosporium herbarum
  Colletotrichum gloeosporioides
  Corticium confluens
  Corticium salmonicolor
  Daldinia concentrica
  Diplodia natalensis
  Graphis afzelii
  Hypoxylon fuscopurpurea
  Lecanidion cyaneum
  Leptothyrium pomi
  Myrthecium verrucaria
  Nectria episphaeria
  Penicillium crustaceum
  Penicillium digitatum
  Penicillium italicum
  Peniophora cinerea
  Peniophora flavido-alba
  Pestalozia guepinia
  Phomopsis citri
  Polystictus occidentalis
  Polystictus pinsitus
  Rhizopus nigricans
  Schizophyllum commune
  Sclerotium Rolfsii
Citrus decumana—*Cont.*
  Septobasidium lilacinum
  Stereum albo-badium
  Stictis radiata
  Tryblidium rufulum
  Ustilina vulgaris
Citrus limonis
  Capnodium citri
  Cephaleuros virescens
  Cladosporium citri
  Diplodia natalensis
  Penicillium digitatum
Citrus nobilis
  Cladosporium citri
  Diplodia natalensis
  Penicillium digitatum
Citrus sinensis
  Alternaria citri
  Aspergillus niger
  Capnodium citri
  Cephaleuros virescens
  Cladosporium citri
  Colletotrichum gloeosporioides
  Corticium salmonicolor
  Diplodia natalensis
  Leptothyrium pomi
  Penicillium digitatum
  Peniophora cinerea
  Phomopsis citri
  Rhizopus nigricans
  Schizophyllum commune
  Stictis radiata
  Stilbella flavida
  Ustilina vulgaris
Cleome pentaphylla
  Cercospora conspicua
Clibadium erosum
  Endophyllum decoloratum
Clidemia hirta
  Meliola melastomacearum

Clidemia strigillosa
Meliola melastomacearum
Clitoria cajanifolia
Uromyces neurocarpi
Clitoria rubiginosa
Uromyces neurocarpi
Clusia gundlachii
Mycosphaerella guttiferæ
Guignardia clusiæ
Clusia minor
Meliola clusiæ
Clusia rosea
Cephaleuros virescens
Clithris clusiæ
Clithris minor
Dimerium melioloides
Ellisiella portoricensis
Mycosphaerella clusiæ
Pestalozzia funerea
Phyllosticta clusiæ
Uredo clusiæ
Coccocypselum repens
Meliola glabra var. psychotriæ
Coccolobis sp.
Cephaleuros virescens
Melasmia coccolobiæ
Meliola prætervisa
Phyllosticta coccolobæ
Coccolobis diversifolia
Cephaleuros virescens
Microclava coccolobiæ
Coccolobis laurifolia
Meliola rectangularis
Coccolobis nivea
Trabutia portoricensis
Coccolobis pyrifolia
Meliola prætervisa
Coccolobis sintenisii
Meliola prætervisa
Coccolobis uvifera
Lembosia coccolobæ

Coccolobis uvifera—*Cont.*
Pestalozzia uvifera
Uredo coccolobæ
Coccothrinax alta
Meliola furcata
Cocos nucifera
Pestalozzia palmarum
Thielaviopsis paradoxa
Coffea spp.
Pellicularia koleroga
Stilbella flavida
Coffea arabica
Cercospora coffeæ
Cercospora coffeicola
Colletotrichum coffeanum
Hemileia vastatrix
Micropeltis longispora
Pellicularia koleroga
Rosellinia bunodes
Stilbella flavida
Coffea excelsa
Stilbella flavida
Coffea Perrieri
Stilbella flavida
Coffea robusta
Stilbella flavida
Colocasia esculenta
Phyllosticta colocasicola
Commelina longicaulis
Illosporium commelinæ
Commelina nudiflora
Phyllosticta commelinicola
Stilbella flavida
Commelina virginica
Illosporium commelinæ
Uredo commelyneæ
Uromyces commelinæ
Comocladia glabra
Meliola comocladiæ
Conocarpus erecta
Meliola laguncularia

- Cordia sp.
  - Meliola longipoda
- Cordia alliodora
  - Puccinia cordiæ
- Cordia collococca
  - Trabutiella cordiæ
- Cordia corymbosa
  - Dimerium Stevensii
  - Meliola longipoda
- Cordia nitida
  - Meliola longipoda
- Cordia sulcata
  - Dimeriella cordiæ
- Cordyline terminalis
  - Phyllosticta maculicola
- Cosmos caudatus
  - Erysiphe cichoracearum
  - Uromyces bidentis
- Cosmos sulphureus
  - Sphærotheca humuli
- Cracca cinerea
  - Ravenelia caulicola
- Crassina elegans
  - Cercospora atricincta
- Crossopetalum pallens
  - Meliola compacta
- Crotalaria retusa
  - Dimerium grammodes
  - Microsphæra diffusa
  - Parodiella perisporioides
- Croton discolor
  - Asterina triloba
- Croton lucidus
  - Phyllosticta portoricensis
- Cucumis anguria
  - Pellicularia Koleroga
  - Peronoplasmopora cubensis
- Cucumis melo
  - Colletotrichum lagenarium
  - Mycosphærella citrullina
  - Peronoplasmopora cubensis
- Cucumis melo—*Cont.*
  - Phyllosticta citrullina
  - Phytophthora terrestria
- Cucumis sativus
  - Colletotrichum lagenarium
  - Peronoplasmopora cubensis
  - Phyllosticta cucurbitacearum
- Cucurbita moschata
  - Peronoplasmopora cubensis
- Cupania sp.
  - Meliola cupaniæ
- Cupania americana
  - Cephaleuros virescens
  - Meliola cupaniæ
  - Meliola prætervisa
- Cuphea parsonsia
  - Uredo cupheæ
- Cydista æquinoctialis
  - Cephaleuros virescens
  - Puccinia cuticulosa
- Cymbopogon citratus
  - Himantia stellifera
  - Melanconium saccharinum
- Cyperus sp.
  - Meliola cyperi
- Cyperus ferax
  - Puccinia canaliculata
- Cyperus giganteus
  - Phyllachora cyperi
  - Puccinia canaliculata
- Cyperus lævigatus
  - Puccinia canaliculata
- Cyperus ligularis
  - Cintractia limitata
- Cyperus odoratus
  - Puccinia canaliculata
- Cyperus polystachus
  - Puccinia canaliculata
- Cyperus radiatus
  - Puccinia canaliculata

Cyperus reticulatus
Puccinia canaliculata
Cyperus sphacelatus
Cintractia axicola
Puccinia canaliculata
Cyperus surinamensis
Puccinia canaliculata

D

Dahlia variabilis
Erysiphe cichoracearum
Dalbergia sp.
Meliola bicornis
Dalbergia monetaria
Meliola bicornis
Datura suaveolens
Alternaria solani
Daucus carota
Sclerotium Rolfsii
Dendropanax arboreum
Cephaleuros virescens
Meliola didymopanicis
Mycosphærella didymopanicis
Phyllosticta araliana
Dendropanax laurifolium
Meliola didymopanicis
Dianthus sp.
Alternaria dianthi
Dichromena ciliata
Uredo dichromenæ
Dichromena radicans
Uredo dichromenæ
Didymopanax morototoni
Mycosphærella didymopanicis
Dieffenbachia seguine
Meliola dieffenbachiæ
Phyllosticta colocasiæ
Diodia littoralis
Puccinia lateritia
Diodia maritima
Puccinia lateritia
Diodia rigida
Puccinia lateritia
Dioscorea alata
Cercospora carbonacea
Dioscorea polygonoides
Uredo dioscoreæ
Dipholis salicifolia
Meliola dipholidis
Dolicholus minimus
Erysiphe polygoni
Uromyces dolicholi
Dolicholus reticulatus
Meliola bicornis
Uromyces dolicholi
Dolichos biflorus
Erysiphe polygoni
Dolichos lablab
Cercospora canescens
Physopella concors
Dorstenia contrajerva
Uredo rubescens
Drymaria cordata
Physalospora caryophyllinicola
Dryopteris mollis
Uredo gymnogrammes
Dryopteris poiteana
Uredo gymnogrammes
Drypetes sp.
Meliola glabra

E

Echinodorus cordifolius
Burrillia echinodori
Eleocharis capitata
Puccinia eleocharidis
Eleocharis cellulosa
Puccinia eleocharidis
Eleocharis flaccida
Puccinia eleocharidis

Eleocharis geniculata
Puccinia eleocharidis
Eleocharis interstincta
Puccinia eleocharidis
Eleocharis mutata
Puccinia eleocharidis
Elephantopus mollis
Coleosporium elephantopodis
Stilbella flavida
Eleutheranthera ruderalis
Puccinia synedrellæ
Emilia sonchifolia
Puccinia synedrellæ
Epidendrum difforme
Uredo guacæ
Epidendrum rigidum
Uredo guacæ
Eragrostis tephrosanthos
Uromyces eragrostidis
Erigeron pusillum
Dimeriella erigeronicola
Erigeron spathulata
Dimeriella erigeronicola
Eriobotrya japonica
Cephaleuros virescens
Eriochloa subglabra
Gibberella pulicaris
Puccinia substriata
Erithalis fruticosa
Meliola psychotriæ
Ernodea littoralis
Puccinia lateritia
Erythrina glauca
Uredo cabreriana
Erythrina micropteryx
Meliola bicornis
Phyllosticta erythrinicola
Erythroxylon areolatum
Uredo erythroxylonis
Eugenia buxifolia
Phyllosticta eugeniæ
Eugenia monticola
Meliola Helleri
Eugenia Stahlii
Meliola Helleri
Eupatorium sp.
Erysiphe galeopsidia (?)
Meliola compositarum
Eupatorium macrophyllum
Coleosporium eupatorii
Eupatorium microstemum
Erysiphe cichoracearum
Eupatorium odoratum
Meliola compositarum
Phyllosticta eupatoricola
Eupatorium polyodon
Puccinia rosea
Eupatorium portoricense
Meliola compositarum var. portoricense
Evolvulus nummularius
Puccinia lithospermi
Exogonium repandum
Phyllosticta ipomoeæ

F

Ficus sp.
Kuehneola fici
Physalospora hoyæ
Ficus carica
Kuehneola fici
Ficus crassinervia
Kuehneola fici
Ficus lævigata
Cephaleuros virescens
Kuehneola fici
Ficus lentiginosa
Kuehneola fici
Ficus nitida
Cephaleuros virescens
Nummularia bulliardii
Ficus reptans
Cephaleuros virescens

Fimbristylis diphylla
  Cintractia axicola
  Puccinia fimbristylidis
Fimbristylis ferruginea
  Cintractia axicola
  Puccinia fimbristylidis
  Uredo superior
Fimbristylis miliacea
  Puccinia fimbristylidis
Fimbristylis spadicea
  Uredo superior
Forsteronia corymbosa
  Meliola tabernæmontanæ v. r. forsteroniæ
Fragaria sp.
  Mycosphærella fragariæ
Fuirena umbellata
  Uredo fuirenæ
Furcræa tuberosa
  Endothia parryi
  Phoma fourcroyæ

G

Galactia dubia
  Meliola bicornis var. galactiæ
Galactia striata
  Phyllachora galactiæ
Galactia tenuiflora
  Phyllachora galactiæ
Garcinia mangostana
  Pellicularia koleroga
Gesneria albiflora
  Meliola gesneriæ
  Nitschkia nervincola
Gomiopteris guadalupensis
  Uredo gymnogrammes
Gonzalagunia spicata
  Meliola psychotriæ
  Wageria portoricensis
Gossypium barbadense
  Cercospora gossypina
  Kuehneola gossypii
  Ramularia areola
Gossypium brasiliense
  Kuehneola gossypii
Gossypium hirsutum
  Kuehneola gossypii
Gouania lupuloides
  Meliola tenuissima
  Puccinia gouaniæ
  Uredo gouaniæ
Gouania polygama
  Puccinia gouaniæ
  Uredo gouaniæ
Graptophyllum pictum
  Rosellinia bunodes
Guarea trichilioides
  Meliola guareæ
  Meliola guareicola
  Phyllosticta guareæ
Guettarda ovalifolia
  Meliola guettardæ
  Meliola psychotriæ
  Septoria ovalifolia
Guettarda scabra
  Meliola psychotriæ
Guilandina crista
  Cercospora guanicensis
  Phyllosticta guanicensis
Gymnanthes lucida
  Meliola gymnanthicola
Gymnogramma sulphura
  Mycosphærella tyrolensis

H

Habenaria maculosa
  Uredo gynandrearum
Hamelia erecta
  Uredo hameliæ

Helianthus annuus
Bacterium solanacearum (?)
Helicteres jamaicensis
Cercospora trichophila
Guignardia helicteres
Phyllosticta borinquensis
Hemidiodia ocimifolia
Aecidium borreriæ
Heterotrichum cymosum
Guignardia heterotrichi
Meliola melastomacearum
Phyllachora peribebuyensis
Hibiscus sp.
Cephaleuros virescens
Hibiscus esculentus
Cercospora hibisci
Choanephora cucurbitarum
Hibiscus sabdariffa
Microsphæra euphorbiæ
Hibiscus tiliaceus
Cercospora hibisci
Meliola triumfettæ
Phyllachora minuta
Hippocratea volubilis
Botryorhiza hippocrateæ
Pestalozzia funerea
Holcus halepensis
Colletotrichum lineole
Puccinia purpurea
Holcus sorghum
Colletotrichum lineola
Puccinia purpurea
Holcus sorghum var. sudanensis
Puccinia purpurea
Hura crepitans
Cercospora huræ
Colletotrichum curvisetum
Hydrocotyle australis
Puccinia hydrocotyles
Hydrocotyle umbellata
Puccinia hydrocotyles
Hygrophila brasiliensis
Meliola irregularis
Hymenæa courbarii
Uredo hymenaeæ
Hymenocallis expansa
Cercospora amaryllidis
Gloeosporium hemerocallidis
Hypelate trifoliata
Meliola glabra
Hypoxis decumbens
Uredo globulosa
Hyptis sp.
Meliola hyptidicola
Hyptis atrorubens
Meliola hyptidicola
Puccinia medellinensis
Hyptis capitata
Meliola hyptidicola
Pseudomeliola collapsa
Puccinia hyptidis
Hyptis lataniflorum
Meliola hyptidicola
Puccinia insititia
Hyptis pectinatum
Meliola hyptidicola
Puccinia medellinensis
Hyptis suaveolens
Puccinia medellinensis

I

Ichnanthus pallens
Dothichloe nigricans
Meliola panici
Puccinia substriata
Ilex nitida
Meliola maricaensis

Indiogofera suffruticosa
  Ravenelia indigoferæ
Inga laurina
  Cephaleuros virescens
  Dimerium truncatum
  Melasmia ingæ
  Meliola toruloidea
  Microstroma
  Perisporium truncatum
  Polystictus maximus
  Ravenelia ingæ
  Stereum caperatum
Inga vera
  Antennularia tenuis
  Cephaleuros virescens
  Dimerium truncatum
  Meliola toruloidea
  Mycosphaerella maculiformis
  Pestalozzia funerea
  Ravenelia ingæ
  Revenelia Whetzelii
  Stilbella flavida
Inodes causiarum
  Graphiola phœnicis
Ipomœa sp.
  Meliola clavulata
  Meliola ipomœæ
Ipomœa angustifolia
  Coleosporium ipomœæ
Ipomœa batatas
  Albugo ipomœæ-panduranæ
  Coleosporium ipomœæ
  Diplodia tubericola
  Meliola clavulata
  Meliola ipomoeæ
  Phyllosticta batatas
  Rhizopus nigricans
  Schizophyllum commune
  Sclerotium bataticola
Ipomœa bona-nox
  Cladosporium herbarum
Ipomœa cathartica
  Meliola clavulata
  Meliola ipomœæ
  Meliola quadrispina
Ipomœa littoralis
  Coleosporium ipomœæ
Ipomœa nil
  Coleosporium ipomœæ
Ipomœa pes-capræ
  Albugo ipomœæ-panduranæ
Ipomœa rubra
  Coleosporium ipomœæ
  Meliola clavulata
Ipomœa stolonifera
  Coleosporium ipomœæ
Ipomœa tiliacea
  Albugo ipomœæ-panduranæ
  Meliola ipomœæ
  Meliola clavulata
Ipomœa triloba
  Puccinia crassipes
Iresine elatior
  Puccinia macropoda
Iresine panniculata
  Cercospora Gilbertii

J

Jacquemontia rodiflora
  Albugo ipomœæ-panduranæ
  Uromyces gemmatus
Jacquemontia tamnifolia
  Albugo ipomœæ-panduranæ
  Coleosporium ipomœæ
Jacquinia barbasco
  Dimerina jacquiniæ
Jacquinia Berterii
  Phyllachora inclusa
Jambosa jambos
  Cephaleuros virescens
  Pestalozzia funerea
  Puccinia psidii

Jatropha curcas
  Uredo jatrophicola
Jatropha gossypifolia
  Uredo jatrophicola
Jatropha hernandifolia
  Meliola jatrophæ
Justicia verticillaris
  Guignardia justiciæ

K

Krugiodendron ferreum
  Meliola thouiniæ
Kyllingia brevifolia
  Puccinia canaliculata
Kyllingia pumila
  Puccinia canaliculata

L

Lactuca intybacea
  Uredo proximella
Lactuca sativa
  Cercospora lactucæ
  Physarum cinereum
Lagenaria leucantha
  Cercospora cucurbitæ
Laguncularia racemosa
  Meliola lagunculariæ
  Meliola nigra
  Mycrothyrium lagunculariæ
  Physalospora lagunculariæ
Lantana sp.
  Meliola ambigua
Lantana camara
  Diatrypella lantanæ
  Meliola ambigua
  Perisporina lantanæ
  Phyllosticta lantanæ
  Puccinia lantanæ
  Septoria lantanæ
Lantana involucrata
  Puccinia lantanæ
Lantana odorata
  Meliola ambigua
Lasiacis divaricata
  Meliola panici
  Uromyces leptodermus
Lasiacis lingulata
  Uromyces leptodermus
Lasiacis ruscifolia
  Meliola panici
Lasiacis Sloanei
  Asterina fumagina
  Meliola panici
  Uromyces leptodermus
Lasiacis sorghoidea
  Cephaleuros virescens
  Meliola panici
  Phyllachora graminis
  Physalospora bambusæ
  Uromyces leptodermus
Leonotis nepetæfolia
  Puccinia leonotidis
Lepidium sp.
  Cercospora lepidii
Lepidium virginicum
  Albugo candida
  Cercospora lepidii
Leptilon canadense
  Dimeriella erigeronicola
Lobelia sp.
  Entyloma lobeliæ
Lobelia assurgens var. portoricensis
  Colletotrichum lobeliæ
Lonchocarpus glaucifolius
  Meliola bicornis
Lonicera japonica
  Cephaleuros virescens
Lucuma multiflora
  Meliola lucumæ
Luffa ægyptica
  Pellicularia koleroga

- Luffa cylindrica
  - Peronoplasmopora cubensis
- Lycopersicum esculentum
  - Bacillus solanacearum
  - Cladosporium fulvum
  - Colletotrichum phomoides
  - Phoma destructiva
  - Phytophthora infestans
  - Phytophthora terrestria
  - Sclerotium Rolfsii
  - Septoria lycopersici

M

- Macrodiscus lactiflorus
  - Meliola furcata
- Magnolia portoricensis
  - Meliola magnoliæ
- Malachra rotundifolia
  - Cercospora malachræ
- Malachra scabra
  - Kuehneola malvicola
  - Puccinia heterospora
- Mammea americana
  - Meliola paullinæ
- Mangifera indica
  - Capnodium mangiferum
  - Cephaleuros virescens
  - Colletotrichum gloeosporioides
  - Meliola mangiferæ
  - Pestalozzia guepinia
  - Stilbella flavida
  - Strigula complanata
- Manihot manihot
  - Cercospora cassavæ
  - Cercospora henningsii
  - Microsphæra euphorbiæ
  - Uromyces janiphæ
- Mariscus jamaicensis
  - Meliola circinans
  - Meliola cyperi
  - Puccinia cladii
- Mayepea domingensis
  - Meliola mayepea
  - Meliola mayepeicola
- Meibomia adscendens
  - Dimerium grammodes
  - Meliola bicornis
  - Microsphæra diffusa
- Meibomia axillaris
  - Cephaleuros virescens
  - Meliola bicornis
  - Uromyces hedysari-paniculati
- Meibomia barbata
  - Dimerium grammodes
- Meibomia scorpiurus
  - Microsphæra diffusa
  - Uromyces hedysari-paniculati
- Meibomia supina
  - Meliola bicornis
  - Microsphæra diffusa
  - Physopella meibomiæ
- Meibomia tortuosum
  - Microsphæra diffusa
  - Uromyces hedysari-paniculati
- Melanthera canescens
  - Sphærotheca humuli
  - Uromyces columbianus
- Melia azedarach
  - Peniophora galachroa
  - Polystictus pavonius
- Melothria guadalupensis
  - Uromyces Hellerianus
- Metastelma lineare
  - Puccinia obliqua
- Metastelma parviflorum
  - Puccinia obliqua
- Miconia sp.
  - Lembosia diffusa
  - Monogrammia miconiæ
  - Napicladium fumago
  - Triposporium stelligerum

Miconia impetiolaris
Cephaleuros virescens
Meliola melastomacearum
Septoria miconiæ
Miconia lævigata
Blastotrichum miconiæ
Borinquenia miconiæ
Cephaleuros virescens
Hyalosphæra miconiæ
Meliola melastomacearum
Microclava miconiæ
Phyllachora peribebuyensis
Septoria miconiæ
Miconia prasina
Meliola miconiæ
Phyllachora peribebuyensis
Miconia racemosa
Meliola melastomacearum
Miconia Sintenisii
Meliola miconiæicola
Phyllachora peribebuyensis
Mikania sp.
Cercospora mikaniacola
Cladosporium mikaniæ
Meliola compositarum
Septoria mikaniæ
Mikania cordifolia
Endophylloides portoricensis
Mikania odoratissima
Endophylloides portoricensis
Mikania scandens
Puccinia Spegazzini
Mimosa ceratonia
Meliola bicornis
Ravenelia cæsalpiniæ
Mitracarpus portoricensis
Meliola psychotriæ
Puccinia lateritia
Momisia iguanea
Phyllosticta momisiana
Mucuna pruriens
Cercospora mucunæ
Mycosphærella mucunæ
Muehlenbeckia platyclada
Cephaleuros virescens
Musa sp.
Antennularia (?) tenuis
Musa paradisiaca
Fusarium cubense
Fusarium radicicola
Glœosporium musarum
Nectria suffulta
Pestalozzia funerea
Stilbella flavida
Myrcia sp.
Cephaleuros virescens
Myrcia deflexa
Cephaleuros virescens
Meliola Helleri
Triposporium stelligerum
Myrcia splendens
Meliola Helleri
Myrica cerifera
Meliola manca

N

Nectandra sp.
Cephaleuros virescens
Nectandra patens
Cephaleuros virescens
Meliola glabroides
Nephrolepis rivularis
Milesia columbiensis
Neurolæna lobata
Puccinia synedrellæ
Nicotiana tobacum
Ascochyta nicotianæ
Bacillus solanacearum
Cercospora nicotianæ

O

Ocimum micranthum
Sphaerotheca humuli

Ocotea leucoxylon
Cephaleuros virescens
Meliola ocoteæ
Meliola ocoteicola

Olyra latifolia
Asterina fumagina
Dimeriella olyræ
Meliola panici
Puccinia deformata

Operculina dissecta
Uredo operculinæ

Oplismenus hirtellus
Phyllachora puncta
Uredo olyræ

Oplismenus setarius
Meliola panici

Opuntia sp.
Diplodia opuntiæ
Perisporiopsis Wrightii

Opuntia dillenii
Septoria fici-indicæ

Ormosia krugii
Puccinia ormosiæ

Oryza sativa
Cercospora oryzæ
Piricularia grisea

P

Palicourea sp.
Meliola glabra var. psychotriæ
Meliola mayaguesiana

Palicourea crocea
Meliola mayaguesiana
Puccinia fallaciosa

Palicourea domingensis
Meliola glabra var. psychotriæ
Meliola mayaguesiana

Palicourea riparia
Meliola mayaguesiana
Puccinia fallaciosa

Panax plumatum
Rosellinia bunodes

Pandanus sp.
Colletotrichum omnivorum
Phyllosticta pandanicola

Panicum barbinode
Uromyces leptodermus

Panicum fasciculatum
Puccinia Huberi

Panicum glutinosum
Meliola panici

Panicum laxum
Ustilaginoidea usambarensis

Panicum maximum
Himantia stellifera
Otthia panici
Phyllosticta panici

Panicum parvifolium
Uromyces leptodermus

Panicum tricanthum
Hypocrella hypoxylon

Panicum trichoides
Puccinia Huberi

Panicum utowanæum
Puccinia Huberi

Parathesis serrulata
Meliola parathesicola

Paspalum conjugatum
Helminthosporium mayaguezense
Myriogenospora Bresadoleana
Phyllachora graminis
Uredo paspalicola

Paspalum fimbriatum
  Puccinia levis
Paspalum glabrum
  Puccinia substriata
  Uredo paspalicola
Paspalum millegrana
  Himantia stellifera
  Phyllachora andropogonis
  Puccinia levis
Paspalum orbiculatum
  Puccinia substriata
Paspalum paniculatum
  Puccinia substriata
  Uredo paspalicola
Paspalum plicatulum
  Claviceps paspali
  Puccinia levis
  Uredo paspalicola
Paspalum portoricense
  Puccinia substriata
Paspalum secans
  Himantia stellifera
  Meliola panici
  Puccinia substriata
Paspalum virgatum
  Phyllachora cornuospora
Passiflora foetida
  Helminthosporium Stahlii
Passiflora rubra
  Aecidium passifloriicola
Passiflora sexflora
  Cercospora biformis
  Phyllosticta superficiale
Paullinia pinnata
  Dexteria pulchella
  Meliola Hessii
  Meliola paulliniæ
Pavonia racemosa
  Uromyces pavoniæ
Peperomia hernandifolia
  Uredo piperis

Persea gratissima
  Meliola perseæ
  Mycosphaerella perseæ
  Phyllachora gratissima
Persicaria portoricensis
  Puccinia polygoni-amphibii
Persicaria punctata
  Cercospora hydropiperis
  Puccinia polygoni-amphibii
Petitia domingensis
  Olivea petitiæ
  Septoria petitiæ
Petiveria alliacea
  Rosellinia bunodes
  Vermicularia atricha
Phaseolus sp.
  Cercosporium beticola
  Erysiphe polygoni
  Phytophthora phaseoli
  Uromyces appendiculatus
Phaseolus adenanthus
  Erysiphe polygoni
  Uromyces appendiculatus
  Zythia phaseoli
Phaseolus lathyroides
  Uromyces appendiculatus
Phaseolus lunatus
  Cercospora canescens
  Cercospora cruenta
  Dimerium grammodes
  Isariopsis griseola
  Physopella concors
Phaseolus max
  Erysiphe polygoni
Phaseolus vulgaris
  Bacterium phaseoli
  Cercospora canescens
  Colletotrichum lindemuthianum
  Erysiphe polygoni
  Isariopsis griseola

Phaseolus vulgaris—*Cont.*
Physarum cinereum
Phytophthora phaseoli
Phytophthora terrestria
Sclerotium Rolfsii
Uromyces appendiculatus
Philodendron krebsii
Colletotrichum philodendri
Meliola philodendri
Phœnix dactylifera
Graphiola phœnicis
Phœnix reclinata
Pestalozzia palmarum
Phyllanthus distichus
Schrœteriaster fenestrala
Phyllanthus grandifolius
Schrœteriaster fenestrala
Phyllanthus niruri
Schrœteriaster fenestrala
Phyllanthus nobilis
Aecidium favaceum
Physalis sp.
Entyloma australe
Phytolacca icosandra
Cercospora flagellaris
Pilea sp.
Meliola Earlii
Pilea nummularifolia
Meliola Earlii
Pilea parietaria
Meliola Earlii
Meliola triloba
Pilocarpus racemosus
Meliola pilocarpi
Piper sp.
Triposporium stelligerum
Piper aduncum
Cercospora portoricensis
Meliola gaillardiana
Piper aduncum—*Cont*
Meliola glabra
Meliola glabroides
Meliola piperis
Piper blattarum
Meliola paucipes
Piper hispidum
Cercospora portoricensis
Meliola contorta
Piper macrophyllum
Stilbella flavida
Piper marginatum
Guignardia pipericola
Piper medium
Cephaleuros virescens
Cyclodothis pulchella
Guignardia pipericola
Meliola tortuosa
Ramularia cylindrosporioides
Piper peltatum
Cercospora portoricensis
Meliola tortuosa
Piper umbellatum
Cercospora portoricensis
Colletotrichum piperis
Meliola tortuosa
Piptadenia peregrina
Ravenelia cebil
Pisum sativum
Cercospora pisa-sativæ
Erysiphe polygoni
Pitcairnia angustifolia
Diachea leucopoda
Pithecolobium saman
Microstroma
Pithecolobium unguis-cati
Colletotrichum erythrinæ
Pestalozzia funerea
Phyllosticta pithecolobii
Phyllosticta pithecolobii var. monensis

Pityrogramma calomelanos
Septoria pityrogrammæ
Uredo gymnogrammes
Pluchea odorata
Uredo plucheæ
Pluchea purpurascens
Uredo plucheæ
Plumiera alba
Coleosporium plumieræ
Plumiera Krugii
Coleosporium plumieræ
Meliola tabernæmontanæ
Plumiera obtusa
Coleosporium plumieræ
Podocarpus coriaceus
Corynelia oreophila
Poinciana pulcherrima
Pestalozzia funerea
Polypodium sp.
Cercospora phyllitidis
Polyscias gailfoylei var. victoriæ
Cephaleuros virescens
Nectria episphæria
Portulaca oleracea
Albugo portulacæ
Prescottia oligantha
Uredo gynandrearum
Pseudelephantopus spicatus
Meliola cyclopoda
Psidium guajava
Cephaleuros virescens
Glomerella psidii
Meliola psidii
Puccinia psidii
Psychotria sp.
Meliola glabra var. psychotriæ
Meliola psychotriæ
Psychotria bertiana
Meliola glabra var. psychotriæ
Psychotria grandis
Meliola glabra var. psychotriæ
Psychotria patens
Puccinia fallaciosa
Psychotria pubescens
Meliola glabra var. psychotriæ
Psychotria uliginosa
Stilbella flavida

Q

Quamoclit coccinea
Coleosporium ipomoeæ

R

Rajania cordata
Uredo dioscoreæ
Randia aculeata
Aecidium abscedens
Meliola psychotriæ
Podosporium pallidum
Rauwolfia nitida
Meliola tabernæmontanæ
Rauwolfia tetraphylla
Meliola tabernæmontanæ
Rhipsalis cassytha
Phæospora cacticola
Rhizophora mangle
Anthostomella rhizomorphæ
Rhynchosia reticulata
Synchytrium decipiens
Ricinus communis
Cercospora ricinella
Rivina humilis
Puccinia rivinæ

Rosa spp.
Actinonema rosæ
Cercospora rosicola
Septoria rosæ
Sphærotheca humuli
Rourea glabra
Micropeltis æruginescens
Roystonea borinquena
Meliola denticulata
Rubus sp.
Meliola puiggarii
Rudolphia volubilis
Meliola rudolphiæ
Triposporium stelligerum
Rynchospora aurea
Cintractia utriculicola
Meliola circinans
Puccinia angustatoides
Rynchospora corymbosa
Cintractia leucoderma
Cintractia utriculicola
Puccinia angustatoides
Rynchospora cyperoides
Guignardia rhynchosporæ
Puccinia angustatoides
Rynchospora distans
Uromyces rhyncosporæ
Rynchospora gigantea
Cintractia leucoderma
Meliola circinans
Rynchospora micrantha
Uromyces rhyncosporæ
Rynchospora setacea
Uromyces rhyncosporæ
Rytilix granularis
Opidiella uredinis
Puccinia levis

S

Sabicea aspera
Uredo sabiceicola
Saccharum officinarum
Arcyria cinerea
Arcyria denudata
Arthrinium saccharicola
Arthrobotrys superba
Aspergillus flavus
Aspergillus niger
Asterostroma cervicolor
Basisporum gallarum
Cercospora longipes
Cercospora vaginæ
Chromocrea gelatinosa
Chromocreopsis striispora
Cladoderris dentritica
Cladosporium herbarum
Colletotrichum falcatum
Corticium arachnoideum
Craterium aureum
Craterium leucocephalum
Cyathus pœppigii
Cytospora sacchari
Dictydium cancellatum
Diplodia cacaoicola
Eurotium argentinum
Fuligo septica
Gibberella pulicaris
Graphium sacchari
Guepinia palmiceps
Guepinia spathulata
Helminthosporium sacchari
Himantia stellifera
Hormiactella sacchari
Hydnum sacchari
Hypocrea rufa
Lachnea cubensis
Lentinus crinitus
Leptosphæria sacchari
Lycogala epidendrum
Lycoperdon albidum
Lycoperdon pusillum
Lycoperdon pyriforme

Saccharum officinarum—*Cont.*
- Marasmius borinquensis
- Marasmius Hiorami
- Marasmius sacchari
- Marasmius synodicus
- Melanconium sacchari
- Melanconium saccharinum
- Merulius byssoideus
- Monilia sitophila
- Myrothecium verrucaria
- Nectria flavociliata
- Nectria laurentiana
- Odontia sacchari
- Odontia saccharicola
- Peniophora cinerea
- Peniophora flavido-alba
- Periconia sacchari
- Phyllosticta sacchari
- Physalospora tucumanensis
- Physarum compressum
- Physarum nodulosum
- Polystictus occidentalis
- Polystictus sanguineus
- Polystictus sinuosus
- Rosellinia paraguayensis
- Rosellinia pulveracea
- Schizophyllum commune
- Scirrhia lophodermioides
- Sclerotium griseum
- Sclerotium Rolfsii
- Scytinotus distantifolius
- Septonema sacchari
- Spegazzinia ornata
- Sphaerella sacchari
- Sphærobolus stellatus
- Stemonitis fusca
- Stemonitis splendens
- Tetracoccosporis sacchari
- Tetraploa aristata
- Thielaviopsis paradoxa
- Trametes nivosa

Saccharum officinarum—*Cont.*
- Tremellodendron simplex
- Trichoderma lignorum
- Tubercularia saccharicola
- Valsa sacchari
- Valsaria subtropica
- Vermicularia graminicola
- Verticicladium graminicolum
- Xylaria apiculata

Sabinea punicea
- Uromyces sabineæ

Salvia coccinea
- Puccinia farinacea

Salvia occidentalis
- Puccinia salviicola

Sauvagesia erecta
- Meliola glabra
- Meliola glabroides
- Uredo sauvagesiæ

Schæfferia frutescens
- Microthyrium Urbani

Schlegelia
- Meliola glabroides var. schlegeliæ

Schlegelia brachyantha
- Phyllachora nitens

Scirpus lacustris
- Puccinia scirpi

Scleria sp.
- Meliola cyperi

Scleria canescens
- Uromyces scleriæ

Scleria cubensis
- Puccinia scleriæ

Scleria hirtella
- Puccinia scleriicola

Scleria pterota
- Phyllachora scleriæ
- Puccinia scleriæ
- Uromyces scleriæ

Sechium edule
  Cercospora sechiæ
  Heminthosporium sechiicolum
  Phyllosticta sechii
Securidaca virgata
  Phyllachora perforans
Serjania polyphylla
  Meliola serjaniæ
Sesamum orientale
  Cercospora sesami
Sida sp.
  Cercospora densissima
Sida carpinifolia
  Asterina sidæ
  Dimerosporium appendiculatum
Sida glutinosa
  Puccinia heterospora
Sida hederifolia
  Puccinia heterospora
Sida humilis
  Puccinia heterospora
Sida procumbens
  Puccinia heterospora
Sida spinosa
  Puccinia heterospora
Sida urens
  Meliola molleriana
  Puccinia heterospora
Simaruba tulæ
  Meliola glabroides
Smilax sp.
  Meliola smilacis
Smilax coriacea
  Meliola smilacis
Smilax domingensis
  Puccinia smilacis
Solanum jamaicense
  Meliola solani
Solanum melongena
  Bacillus solanacearum
  Cladosporium herbarum
  Glœosporium melongenæ
  Phomopsis vexans
  Sclerotium Rolfsii
Solanum nigrum
  Cercospora rigospora
Solanum persicifolium
  Meliola glabroides
Solanum rugosum
  Meliola glabroides
Solanum torvum
  Aecidium tubulosum
  Cercospora trichophila
  Cladosporium fulvum
  Erysiphe cichoracearum
  Puccinia substriata
Solanum tuberosum
  Alternaria solani
  Phytophthora infestans
  Rhizoctonia solani (?)
Solanum verbascifolium
  Cercospora trichophila
Somidesia lindeniana
  Cephaleuros virescens
Spermacoce riparia
  Puccinia lateritia
Spermacoce tenuior
  Puccinia lateritia
Sphenoclea zeylanica
  Cercosporidium Helleri
Spondias mombin
  Meliola comocladiæ
Sporobolus indicus
  Helminthosporium Ravenellii
  Uromyces ignobilis
Sporobolus virginicus
  Uromyces ignobilis
Stenolobium stans
  Prospodium appendiculatum

Stenorrhynchus lanceolatus
Uredo pustulata
Stenotaphrum secundatum
Meliola stenotaphri
Ustilago affinis
Stigmaphyllon lingulatum
Puccinia inflata
Stizolobium sp.
Cercospora mucunæ
Stizolobium aterinium
Cercospora mucunæ
Struchium sparganophorum
Uredo sparganophori
Synedrella nodiflora
Puccinia synedrellæ
Stilbella flavida
Syntherisma digitata
Piricularia grisea
Puccinia substriata
Syntherisma sanguinalis
Mycosphærella maydis

T

Tabebuia hæmantha
Meliola bidentata
Mycosphærella tabebuiæ
Tabernæmontana oppositifolia
Meliola tabernaemontanæ
Tagetes erecta
Puccinia tageticola
Tagetes patula
Puccinia tageticola
Tamonea sp.
Hypocrella tamoneæ
Tecoma sp.
Meliola tecomæ
Tecoma pentaphylla
Meliola bidentata
Meliola tecomæ
Prospodium plagiopus
Tectaria martenicnsis
Uredo gymnogrammes
Teramnus uncinatus
Cercospora maricaoensis
Meliola bicornis
Uredo concors
Uromyces cologaniæ
Tetragastris balsamifera
Meliola amphitrica
Tetrazygia sp.
Guignardia tetrazygiæ
Phyllachora peribebuyensis
Thalia geniculata
Puccinia cannæ
Theobroma cacao
Cephaleuros virescens
Colletotrichum Cradwickii
Creonectria Bainii
Diplodia cacaoicola
Nectria colorans
Thouinia sp.
Cladosporium hypophloem
Thouinia striata
Cercospora thouiniæ
Meliola thouiniæ
Thrinax
Helminthosporium spiculiferum
Thrinax ponceana
Meliola furcata
Thrinax præceps
Graphiola phœnicis
Meliola furcata
Tournefortia bicolor
Aecidium tournefortiæ
Tournefortia hirsutissima
Aecidium tournefortiæ
Meliola longipoda
Tournefortia microphylla
Aecidium tournefortiæ

Trichilia pallida
  Uredo trichiliæ
Trichostigma octandrum
  Cercospora trichostigmæ
  Linospora trichostigmæ
  Puccinia rivinæ
Triticum vulgare
  Sclerotium Rolfsii
Triumfetta lappula
  Pucciniosira pallidula
Triumfetta rhomboidea
  Pucciniosira pallidula
Triumfetta semitriloba
  Meliola triumfettæ
  Phyllosticta Stevensii
  Pucciniosira pallidula
Turpinia paniculata
  Meliola guignardi

U

Urechites lutea
  Phyllosticta glaucispora

V

Vachellia farnesiana
  Ravenelia siliquæ
Valerianodes cayennensis
  Endophyllum stachytarphetæ
  Meliola glabroides
Valerianodes jamaicensis
  Puccinia Urbaniana
Valerianodes strigosa
  Puccinia Urbaniana
Valota insularis
  Phyllachora graminis
  Puccinia substriata
  Sphacelotheca panici-leucophæi
Vanilla Eggersii
  Glomerella cingulata
Vanilla planifolia
  Cephaleuros virescens
  Fusarium solani
  Glœosporium (vanillæ) rufomaculans
  Pellicularia koleroga
Varronia sp.
  Helminthosporium varroniæ
  Meliola mølleriana
Varronia alba
  Metasphæria abortiva
Verbena sp.
  Sphærotheca humuli
Vernonia albicaulis
  Argomyces insulanus
  Argomyces vernoniæ
Vernonia borinquensis
  Argomyces vernoniæ
Vernonia longifolia
  Argomyces insulanus
Vernonia phyllostatchya
  Argomyces vernoniæ
Vicia faba
  Sclerotium Rolfsii
Vigna repens
  Dimerium grammodes
  Erysiphe polygoni
  Uromyces appendiculatus
Vigna vexillata
  Hyponectria phaseoli
  Uromyces appendiculatus
Vigna unguiculata
  Cercospora cruenta
  Cercospora vignæ
  Erysiphe polygoni
  Physarum cinereum
Viola sp.
  Cercospora violæ
  Gloeosporium violæ

Vitex divaricata
Ophiobolus barbatus
Vitis vinifera
Physopella vitis

W

Wedelia lanceolata
Uredo vicina
Wedelia reticulata
Uromyces pianhyensis
Wedelia trilobata
Endophyllum wedeliæ
Willoughbæa sp.
Meliola compositarum
Winterana canella
Meliola thouiniæ
Triposporium stelligerum
Wissadula periplocifolia
Puccinia heterospora

X

Xanthium longirostre
Puccinia xanthii
Sphærotheca humuli
Xanthosoma sagittifolium
Periconia pycnospora

Z

Zamia integrifolia
Triposporium stelligerum
Zea mays
Helminthosporium turcinum
Himantia stellifera
Phyllachora maydis
Sclerotium griseum
Uredo pallida
Ustilago zeæ
Zornia diphylla
Puccinia zorniæ

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INSECTS ATTACKING VEGETABLES IN PORTO RICO.

By R. T. COTTON, Former Entomologist, Insular Experiment Station.

The growing of vegetable crops in Porto Rico is attended by a great many difficulties, not the least of which is that due to the ravages of insects.

Vegetable crops are peculiarly susceptible to insect attacks, more so than the majority of other crops, and it has been estimated that a loss of no less than 20 per cent of the total value of the crop is caused by their ravages.

In order to successfully fight these pests and so reduce this loss it is necessary to know something of the nature of these insects, their intimate life histories, and their methods of attack. It is with the object of presenting the more important facts about these insects, together with the best known methods of combating them, that this article has been prepared.

Much of the material for this paper has been taken from the experiments and notes of this station, and is here presented for the first time, although information has been freely taken from the various standard works on insects injurious to vegetables, and from publications of various Experiment Stations and of the United States Bureau of Entomology.

ACKNOWLEDGMENTS.

Many thanks are due to Dr. L. O. Howard for his kindness in permitting the use of many of the illustrations that appear in this text, and which originally appeared in publications of the U. S. Bureau of Entomology. We are also indebted to him for the determinations of many of the insects discussed in the following pages. Credit is due to Mr. Eugene G. Smyth for many of the photographs from which illustrations have been made.

GENERAL CONSIDERATIONS.

Before taking up a discussion of any one particular insect in its relation to vegetables it would be well to consider the subject of insects in general, their differences in structure and habits, and the significance of these factors with regard to the methods employed to control them.

Insects may be roughly divided into two general classes, those possessing biting mouthparts and those with sucking mouthparts. To the first class belong grasshoppers, leaf-feeding beetles, and caterpillars. To the second, such insects as plant lice, scale-insects, bees, and true bugs. Insects of the first class may usually be destroyed by the use of stomach poisons, but this form of control is useless for the second class, which must be hit by a contact spray in order to be killed.

Most insects pass through a number of different changes in form before becoming adults. Some such as the grasshoppers and true bugs have what is known as an incomplete metamorphosis. They hatch from the egg into forms resembling the adults, but differing usually in size and in lacking certain organs such as wings. This stage between the egg and adult is known as the nymphal stage. Other insects such as the butterfly, beetle, and bee have what is known as a complete metamorphosis. On leaving the egg they assume a form entirely different from the adult. This is the larval or grub stage, an active feeding stage. After this stage they change to a pupal or resting stage, and finally to the adult forms.

These stages differ remarkably in form and habit in the different species of insects. Some are passed in the soil, others in the air, some on the foliage of plants, and some within the stems and tissues of the host plant itself.

A careful study of all stages in the life of an insect will usually reveal a weak spot, and advantage may be taken of this in controlling the pest.

CONTROL MEASURES.

Control measures are numerous and varied, but may be all roughly classified under the two main groups, direct and indirect.

Indirect measures are mostly preventive and consist of any practice that does away with conditions favorable to injurious insect life. Clean cultivation, the destruction of weeds and trash that harbor destructive insects, the intelligent rotation of crops, the planting of clean seed, the use of hardy seedlings, the proper use of

fertilizers, the use of trap crops, and the protection of the natural enemies of insect pests all have their uses in reducing the loss caused by insects, and often constitute the most effective means of keeping some of the worst pests under control.

Direct measures are those that kill by mechanical methods, stomach poisons, contact sprays, or fumigation.

MECHANICAL METHODS.

Under this head comes the practice of collecting insects in order to destroy them. This may be done by hand-picking, sweeping them into nets, catching them on various kinds of sticky surfaces, or by catching them with trap lights. Many types of insects may be controlled by these methods when no other way is feasible.

STOMACH POISONS.

The best known and most commonly used stomach poisons in insect control are the various arsenical compounds. The most effective of these are discussed below.

Arsenate of Lead.—This is an excellent poison, and is used more extensively than any other arsenical in the control of leaf-eating insects. It may be used either as a liquid spray or in the form of dust and is effective both ways. For most leaf-eating insects it is usually used at the rate of one pound of the powder form, or two to three pounds of the paste to one hundred gallons of water. Applied in dust form it is very effective and is peculiarly adapted to Porto Rican conditions. It should be mixed with an equal part of air-slacked lime, or dry, leached wood ashes, and may be applied by shaking from a cheese-cloth bag, or by the use of a dust gun.

Paris Green.—This is probably the best known of the arsenicals used in insect control, and it is a very strong and deadly poison. It is excellent for use in the preparation of poison baits, but owing to its tendency to burn delicate foliage, it is being displaced as a leaf spray, by the newer and safer arsenicals.

Two other arsenicals that are coming into favor and are giving excellent results in insect control are calcium arsenite and zinc arsenite. These both come in the same form as arsenate of lead, and may be used in a similar manner.

CONTACT INSECTICIDES.

The various concoctions of kerosene, tobacco, and soap are the standard contact sprays and may be used against all soft-bodied sucking insects.

Kerosene emulsion, when properly made and applied, is one of the best of these and may be used against the hardier insects. When used on tender plants there is some danger of burning the foliage unless great care it taken in the preparation and dilution of the stock. The formula and directions for making the stock solution are as follows:

Kerosene	2	gallons.
Soap	½	pound.
Water	1	gallon.

Dissolve the soap in boiling water and pour while boiling into the kerosene. This mixture should be emulsified quickly by pumping it back into itself with a force pump for about five minutes. Properly prepared it should have the consistency of thick cream and should hold up indefinitely.

For ordinary use on vegetable crops this stock solution should be diluted at the rate of one part of stock to fifteen parts of water.

Tobacco.—Tobacco is used in several different forms against soft-bodied insects, as a dust, as a liquid spray, and as a fumigant.

Nicotine sulphate is the most effective of these tobacco extracts and, owing to its good qualities and ease of preparation, is taking the place of kerosene emulsion in the control of a great many of the soft-bodied insects. It is a standard solution containing 40 per cent by weight of nicotine, and is sold under a trade name. It is usually used at the rate of one part of stock to a thousand parts of water, with soap added at the rate of three pounds to fifty gallons of spray.

Tobacco concoction.—This is a somewhat weaker tobacco solution, but is quite effective in the control of plant lice. It is made by boiling tobacco stems, leaves or refuse in water at the rate of one pound to one gallon of water. This stock solution may be diluted slightly according to the resistance of the insect it is used against.

Tobacco papers.—These are made by soaking strips of paper in tobacco extract. In the control of plant lice on melons and similar plants, these are sometimes burned under frames thrown over the plants, the fumes given off killing the lice.

Soap.—Any good soap may be used as a wash for controlling plant lice and other soft-bodied insects. It is not so effective, however, as kerosene emulsion or the combination of tobacco extract and soap, but may be used when other materials are not available. Fish-oil soap is cheap and is one of the best to use. This and other soaps should be used at the rate of one pound to six or eight gallons of water.

STICKERS AND SPREADERS.

Some plants have a waxy or very smooth foliage to which the ordinary spray does not readily adhere. To remedy this it is necessary to add to the spray a so-called sticker or spreader. The following are a few of the best of these:

Ordinary soap added at the rate of one pound to five gallons of the spray is effective in making it stick better.

Two pounds of resin and one pound of sal soda (crystals) boiled for an hour in a gallon of water make an excellent compound for the purpose. This amount is sufficient for forty gallons of spray.

GENERAL FEEDERS.

There are a great many insects that do not confine their attacks to one particular crop, but feed on practically all vegetables indiscriminately. These are known as general feeders and are treated separately as follows:

ANTS.

Ants, which are so well known to everyone, are occasionally troublesome in the garden. They are very fond of some kinds of seeds, and will often eat the entire soft part of the seed, leaving nothing but the empty shell. At other times they will carry off the seeds bodily to their nests, where they later devour them.

The "fire ant" (*Solenopsis geminata*) occasionally feeds on the stems and fruits of some vegetables, building runways of earth over both stems and fruit.

Indirectly they cause further damage by starting colonies of plant lice on the various vegetable crops, taking care of them and moving them from plant to plant in return for a sweetish substance secreted by the lice.

Control.—The most effective method of controlling these pests is to destroy their nests. This may be accomplished by pouring a little carbon bisulphide into the nest, and then packing the earth down over the entrance holes so that the evaporating carbon bisulphide will not escape into the air, but will spread through the soil and kill the ants. Another method is to spray the nests thoroughly with an emulsion of carbolic acid and soap. This spraying should be repeated the following day to insure the destruction of all the ants. The emulsion may be made as follows:

Water	1	quart.
Soap	½	pound.
Carbolic acid (crude)	1	pint.

Dissolve the soap in the water, then add the crude carbolic. Finally add enough water to make two quarts of solution. For use, this stock solution should be diluted at the rate of one pint of stock to six gallons of water.

THE CHANGA.

The changa or mole cricket, *Scapteriscus vicinus*, attacks a majority of the vegetables grown in Porto Rico, and is especially destructive in the sandy-loam soils of the coastal regions.

These rather ferocious looking insects (Fig. 24), with their fore legs peculiarly adapted for digging and excavating, make galleries or runways just beneath the surface of the soil, where hidden from sight they can travel in safety from one plant to another. They feed chiefly on the roots of living plants, and the stems and foliage of young seedlings that have just been set out in the field. They feed usually at night and are frequently to be seen around the houses in the evenings, where they have been attracted by the lights.

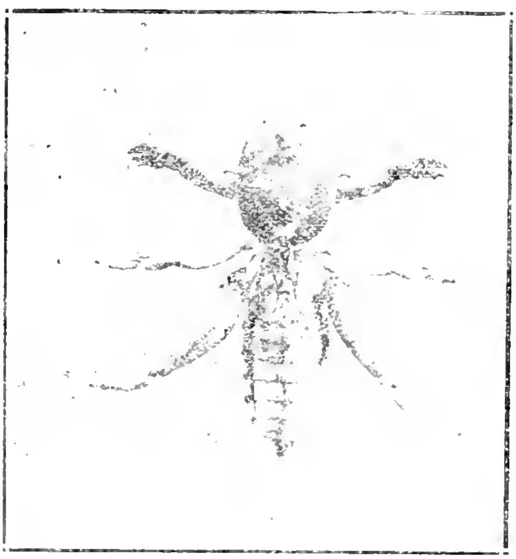

Fig. 24. The Changa (*Scapteriscus vicinus*). Adult.

Control.—Fortunately these insects are readily controlled by the use of a poison bait.[1] made as follows:

	Pounds.
Flour (low grade)__	100
Paris green________	3

Mix these two ingredients thoroughly, and broadcast the resulting mixture over the prepared ground about a week before the vegetables are planted or protect each individual plant by placing about a spoonfull of the mixture in a shallow trench around the plant. Either of these methods will prove very effective in controlling the changa.

CRICKETS.

The so-called "sick cricket" *Amphiacusta caribbea*, is another insect that feeds indiscriminately on vegetable crops. It is nocturnal in habit, hiding during the day under trash or in craks in the soil.

[1] S. S. Crossman and G. N. Wolcott, Circ. No. 6, Board of Comm. of Agric. of P. R. Insular Exp. Sta.)

and coming out at night to feed. It often occurs in great numbers and at these times is very destructive.

Control.—It may be very effectively controlled by the use of a poison bait as described for use against grasshoppers.

FIG. 25.—Cricket (*Amphiacusta caribbea*). Adult.

CUTWORMS.

These inconspicuously colored caterpillars are the immature forms of a large family of moths called the Noctuids. They are usually somewhat brownish in color, mottled with markings of gray, yellow, or black. They are naked or only sparsely clothed with hairs, and vary in length from one to two inches when full grown.

They feed chiefly during the night, hiding during the day beneath clumps of earth or in cracks in the soil, their inconspicuous colors bleding so well with the soil that it is difficult to see them.

FIG. 26.—Cutworm. A larva boring into a bean pod.

They often cause great damage by feeding on the foliage of young plants, and cutting them off just as the young plants are pushing through the ground. Hence their name of "cutworms."

Control.—These cutworms are generally kept pretty well under control by their natural enemies. They are preyed upon by lizards, birds, spiders, ground beetles, Tachinid flies, and Hymenopterous parasites.

When they become very numerous, however, they may be controlled by the use of a poison bait, as recommended for the grasshoppers (Page 272). This bait should be scattered over the soil around the plants in the early evening.

FLEA-BEETLES.

The flea-beetles, so called from their habit of jumping suddently from one plant to another when disturbed, are small leaf-eating beetles belonging to the family *Chrysomelidæ*.

Some of them are more or less general feeders and cause great damage by riddling the leaves with their feeding punctures.

The worst of these is the so-called "pulga americana," *Systena basalis*, which feeds indiscriminately on nearly all vegetable crops. The larva of this beetle feeds on the roots of weeds and some cultivated plants, but does not cause a great deal of damage.

In addition to the direct injury caused by feeding, the flea-beetles undoubtedly transmit diseases from one plant to another.

Control.—Excellent results may be obtained by keeping the plants dusted with a mixture of equal parts of arsenate of lead and hydrated or air-slacked lime or dry, leached, wood-ashes. Two applications a week when the beetles are numerous will effectively control them.

GRASSHOPPERS.

There are some three or four species of grasshoppers that are occasionally to be found doing damage in the garden. They feed indiscriminately on the tender truck crops, but are rarely numerous enough to cause any serious damage.

FIG. 27.—Grasshopper. Adult.

Control.—Lizards and birds to a great extent keep these pests from becoming numerous enough to do much damage. When they do appear in destructive numbers, they may be effectively controlled by the use of a poison mash. The formula and directions for making it follow:

Bran or corn meal	25 pounds.
Paris green or white arsenic	1 pound.
Molasses (low grade)	3 pints.
Oranges	6

The bran or meal should be mixed with the molasses and the sliced oranges, and enough water to make the whole mixture moist. The paris green or white arsenic should then be added and stirred in well.

This bait should be scattered broadcast through the infested field in the early evening. It should not be distributed during the day as the heat of the sun would soon dry it up, and it would lose most of its effectiveness.

LEAFHOPPERS.

Leafhoppers are usually quite abundant in the garden and often do a great deal of damage. They are delicate little insects with long

hind legs specially fitted for jumping. As soon as the vegetation on which they are feeding is disturbed they hop into the air in small clouds, and fly off to nearby plants.

They cause damage by sucking the plant juices from the foliage, thus sapping the vitality of the plant and often causing the leaves to curl and dry up. They attack a great variety of vegetables, and although most of them prefer one particular plant, some of them will attack a great number. This is particularly true of the apple leafhopper, *Empoasca mali*, but this pest will be discussed in greater detail as a pest of the bean.

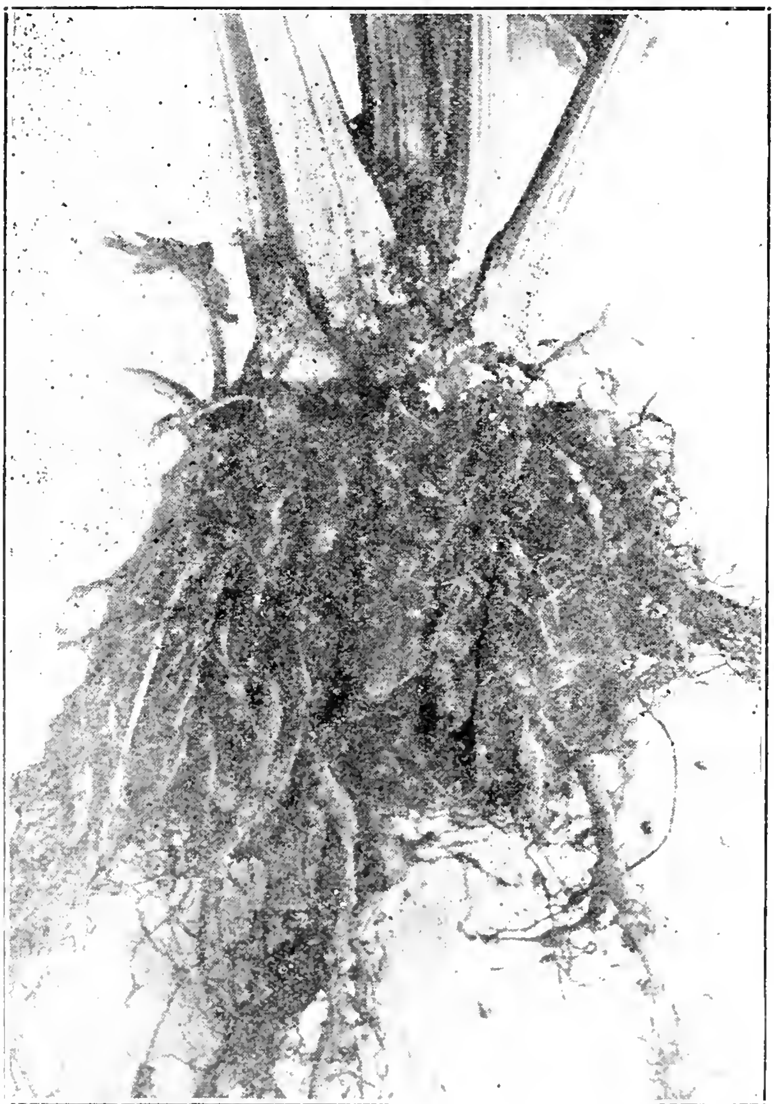

Fig. 28.—Nematodes (*Heterodera radicicola*). Showing [illegible].

Control.—Leafhoppers being sucking insects cannot be poisoned, but must be hit with a contact spray in order to kill them. A soap and nicotine sulphate spray as described on page 268 is effective in killing a large number of them if properly applied. The spray should be applied as fine as possible and to the undersides of the leaves. Sticky surfaces may also be used very effectively in catching the hoppers. These should be carried along the rows of plants, and the hoppers caught as they fly up on being disturbed.

NEMATODES.

A great many of the vegetable crops are attacked to a greater or less extent by a minute thread-like worm, *Heterodera radicicola*, which bores into the roots, causing them to swell, and stunting or stopping the growth of the plant. Fig. 28 shows the work of this worm or nematode on the roots of celery.

Control.—Ground that is known to be infested with these worms should be planted only to crops that are resistant or immune to their attacks. Seedlings should be grown in sterilized seed-beds. Infested land may be treated with applications of wood ashes, lime, or salt to reduce the number of nematodes or with Cyanamid [1] at the rate of from one to three tons per acre.

SLUGS OR LAPAS.[2]

FIG. 29.—Slug.

These slimy, repulsive looking creatures are very destructive to all green crops, and occasionally do great damage to some vegetables. They are nocturnal in habit, hiding during the day and coming out to feed at night. It is usual during a season of heavy rains for them to occur in destructive numbers.

Control.—The lapas may be cleared from a field by collecting them at night with the aid of lanterns. They may also be controlled by placing fresh-cut leaves between the rows of plants in the evening, and collecting in the morning the lapas that have crawled under them. A light application of lime on the soil around the plants is also effective in protecting them from the lapas.

WHITE GRUBS.

There are several species of white grubs that do damage to our truck crops. These grubs are the immature forms of the large brown beetles known as "May beetles" or "June bugs." They are large, fleshy, wrinkled, white grubs, that lie curled in a semi-circle

[1] Watson, J. R., Florida Agric. Exp. Sta. Bul. 136.

[2] *Veronicella occidentalis.*

in the soil around the roots of a great variety of plants. Although provided with three pairs of legs, they are not able to walk. The head is light brown in color, and has well developed mouthparts.

These white grubs have a life cycle of about one year in duration. The eggs are laid in the soil and hatch in about two weeks. The grub stage then lasts for a period varying from six to twelve months. It is during this larval or grub stage that the damage is done to the vegetable crops, the grubs trimming off the tender young roots and girdling the larger ones so that the affected plant soon dies. When full grown the grub changes to the pupal or resting stage which lasts for about a month. Then it changes to the adult beetle which emerges from the soil to mate and feed.

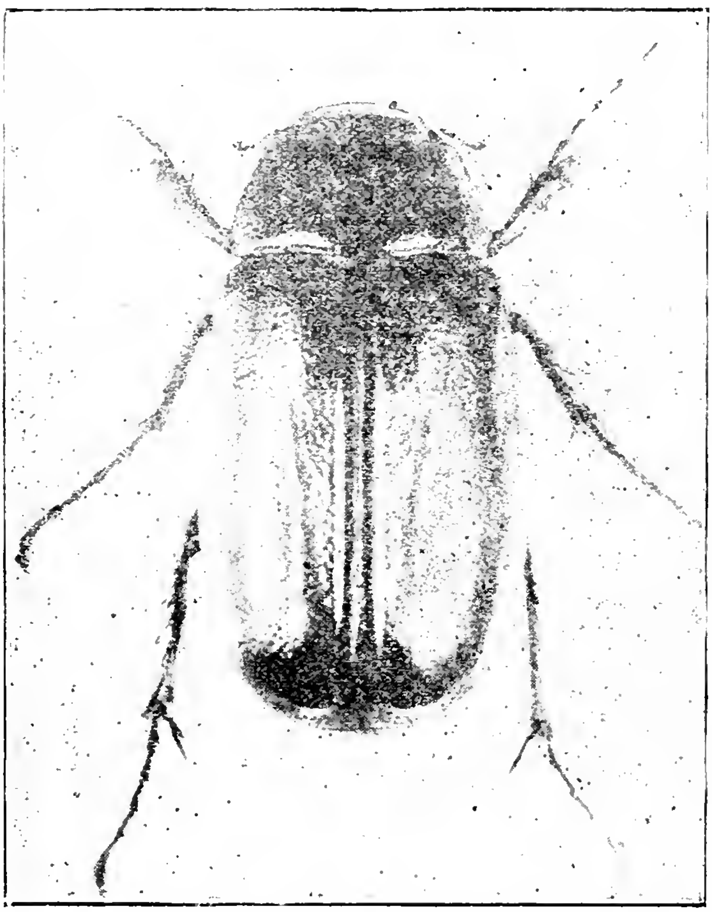

FIG. 30.—May-Beetle (*Phyllophaga* sp.). Adult.

Control.—It is very difficult to control these pests, and no very satisfactory or practical methods have as yet been discovered for entirely getting rid of them.

In general, crop rotation should be practiced, the grubs should be collected by hand when the land is plowed, and when possible, land known to be infested with the grubs should not be planted to vegetable crops.

BEANS.

BEAN LEAF-BEETLE (*Cerotoma ruficornis*).

Of considerable importance to bean growers is the bean leaf-beetle (Fig. 32). It is a small, reddish-brown beetle with black

markings, and usually becomes very abundant wherever beans are grown.

Feeding on the leaves, the beetles when abundant strip them to the veins and mid-ribs, causing great damage. They deposit their yellowish-colored eggs in the soil around the roots of the plant. These hatch in a few days and the whitish larvæ that emerge feed on the roots and nodules of the bean, causing additional damage.

Control.—If, when the beetles first begin to appear, the plants are thoroughly sprayed with arsenate of lead, three pounds in fifty gallons of water, little trouble will be experienced from them.

BEAN LEAF-HOPPER (*Empoasca mali*).

FIG. 31.—White Grub (*Phyllophaga* sp.). Larva.

This leaf-hopper, known in the United States as the apple leaf-hopper, is always in great abundance in the garden. It attacks a great variety of plants, but its greatest damage is done to the bean.

The leaves of the bean are curled and distorted, and the edges turn yellow and dry up. This is caused by the sucking of the juices from the tissues, and results in a serious stunting of the plants and a consequent decrease in the yield.

The hopper itself is a small, delicate, green insect with a life cycle of a little less than three weeks. This short life cycle makes it possible to increase in numbers with extreme rapidity.

Control.—This insect is attacked by a fungus, *Sporotrichum globuliferum*, which helps somewhat to keep it in check. The methods given for controlling leaf-hoppers in general (page 273) may be used on this insect with good results.

BEAN LEAF-MINER (*Agromyza jucinda*).

The leaves of the bean are occasionally mined by the grub of a small Agromyzid fly, but it is parasitized so heavily that it never causes an appreciable amount of damage, and no control measures are required.

BEAN LEAF-ROLLER (*Eudamus proteus*).

The larva of this swallow-tailed skipper, known as the bean leaf-roller, is usually to be found feeding on the leaves of the bean.

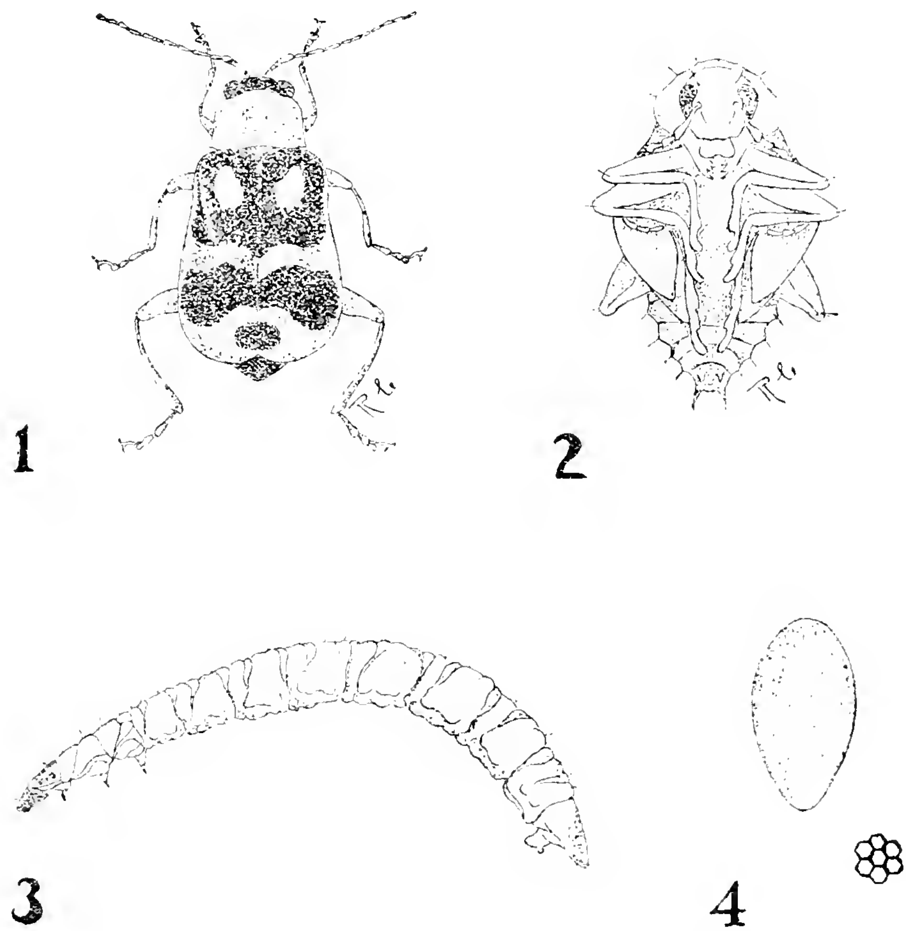

FIG. 32.—Bean Leaf-Beetle (*Cerotoma ruficornis*). 1, adult; 2, pupa; 3, full-grown larva; 4, eggs. All much enlarged.

Forming a characteristic shelter by rolling up the edges of the leaf, the larva hides within, coming out at times to feed on the foliage immediately around it.

The handsome green larva is readily distinguished from other pests of the bean by the narrow constricted neck that joins the prominent brown head to the velvety green body.

The bluish-green adult known as a skipper butterfly may be seen darting rapidly here and there among the bean plants, occa-

sionally stopping to deposit eggs on the foliage, or to feed upon the nectar of the flowers. These eggs soon hatch, and the larvæ feed upon the foliage for a period of about two weeks, after which they change to pupæ and later to adults.

FIG. 33.—Bean Leaf-Hopper (*Empoasca mali*). Adult and enlarged wing. (U. S. Bureau of Entomology.)

Control.—This pest never becomes excessively abundant owing to the good work of a small hymenopterous insect that parasitizes the larvæ. When troublesome, however, it may be readily controlled by spraying the affected plants with an arsenate of lead spray, at the rate of one and a half pounds of arsenate of lead to fifty gallons of water.

BEAN LEAF-WEBBER (*Nacoleia indicata*).

The larva of this small pyralid moth is always more or less abundant on the foliage of the bean. The small dirty-green colored larva webs the leaves together, living between them and skeletonizing them with its feeding. It has a very short life cycle and multiplies rapidly.

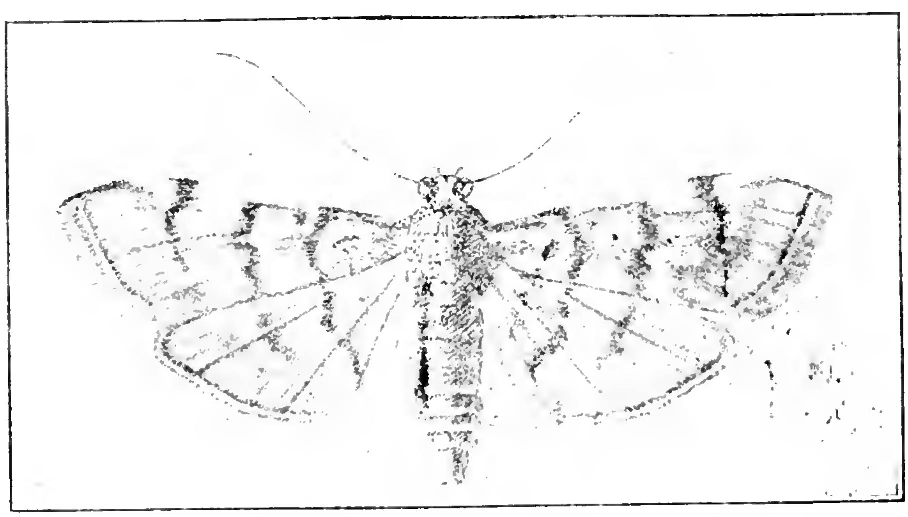

FIG. 34.—Bean Leaf Webber (*Nacoleia indicata*). Male moth. Enlarged. (U. S. Bureau of Entomology.)

The adult moth is golden yellow in color, the two pairs of wings being marked with several transverse, dark, wavy lines.

Control.—This pest may be controlled by spraying the leaves with an arsenate of lead spray, two pounds of the poison to fifty gallons of water.

BEAN POD-BORER (*Maruca testulalis*)

The pinkish-white larva of this moth is frequently served on the table with string beans. It has the habit of boring into the green pods, and while not generally abundant is occasionally troublesome.

The adult is a very handsome pyralid moth, front wings a dark, almost golden brown with a large irregular white mark and two smaller ones, hind wings silvery white, bordered on the outer margin with an irregular, brown patch.

Control.—Infested pods should be collected and destroyed. An arsenate of lead spray as recommended for the preceding species, would kill a great many of the larvæ before they could eat their way into the pods.

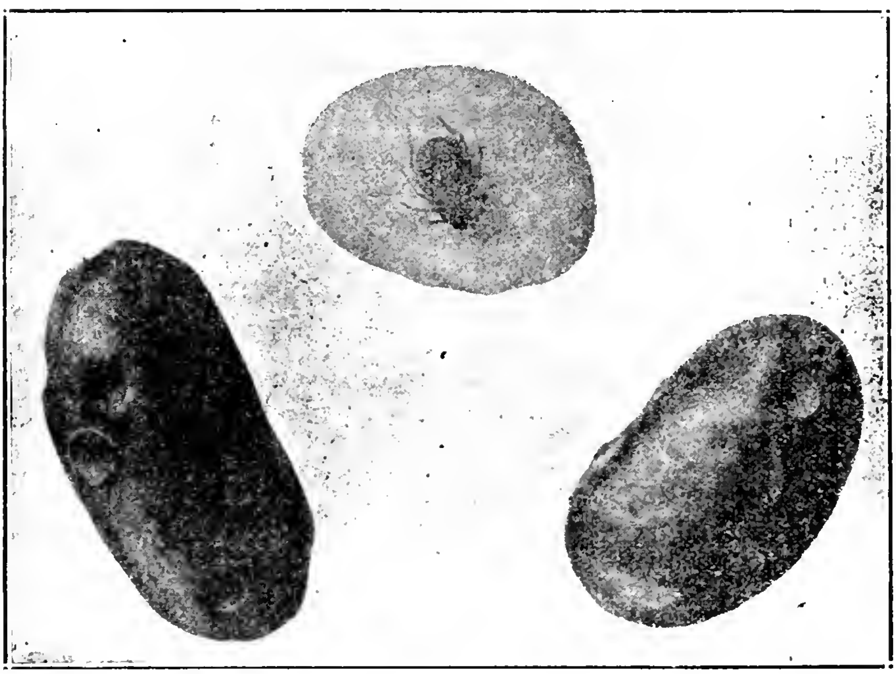

FIG. 35.—Bean Weevil (*Bruchus obtectus*). Showing nature of injury and adult weevil.

BEAN WEEVILS.

Several species of weevils attack beans and cowpeas destroying the seeds. The commonest of these are *Bruchus obtectus* and *Bruchus quadrimaculata*.

These weevils begin their depredations in the field, but the greatest injury occurs after the beans have been harvested and placed in storage. If the seed is not protected by fumigations, or by being kept in weevil proof containers, they will be completely destroyed by the weevils, and in a very short space of time.

In the field the female weevils deposit eggs in small cavities eaten out of the pod. Small white grub-like larvæ hatch in a few days and complete their development within the seeds.

Practically nothing can be done to combat the weevils in the field, but fortunately the injury there is comparatively slight, and it is only after the seed has been gathered and stored that the real damage is done. To prevent this the beans should be kept in airtight containers, and should be fumigated whenever weevil injury is apparent.

OTHER BEAN PESTS.

Insects of minor importance that attack the bean are: aphids (see General Feeders, page 269); plant bugs, *Euschistus bifibulus* and *Piezodorus guildingi* (see Tomato, page 310); *Ecpantheria eridanus* (see Celery, page 285); flea-beetles (see General Feeders, page 271); grasshoppers, *Schistocerca columbina*, *Plectrotettix gregarius*, etc. (see General Feeders, page 272); *Laphygma frugiperda* which bores into the pods (see Corn, page 288); leaf-hoppers (see General Feeders, page 272); red spider, *Tetranychus* sp. (see Green Peas, page 304); and thrips, page 305.

BEETS.

THE SOUTHERN BEET WEBWORM (*Pachyzancla bipunctalis*).

This is a very common and abundant webworm on beets, chard, and weeds of the genus *Amaranthus*. It does considerable damage to the beet, skeletonizing the leaves where it webs them together to form a feeding shelter.

The adult is a small, glistening, yellowish-brown moth with a few faint, transverse, wavy, dark lines across the wings. It deposits four or five small, flat, over-lapping, scale-like eggs on a leaf at one time. These hatch into small, yellowish larvæ that feed on the leaves for about ten days before changing to pupae and then to adults.

Control.—The larvæ may be readily controlled by spraying the plants with arsenate of lead, three pounds in fifty gallons of water, or by dusting them with a mixture of equal parts of arsenate of lead and hydrated or air-slaked lime.

THE SMALL BEET WEBWORM (*Zinckenia fascialis*).

The larvæ of this moth occur frequently along with those of the preceding species, and although not so abundant, do the same kind of damage, the webbing and skeletonizing of the leaves.

The larva of this species looks very similar to that of the preceding species, but the adult is dark brown in color, with transverse white bands across the wings.

Control.—Methods of control are the same as for the preceding species.

OTHER BEET PESTS.

Other insects attacking beets are: *Nacoleia indicata* (see Beans, page 275); *Systena basalis* (see Carrots, page 284); *Xylomeges sunia* (see Chard, page 287); leaf-hoppers (see General Feeders, page 272).

CABBAGE.

THE DIAMOND-BACK MOTH (*Plutella maculipennis*).

This minute moth is undoubtedly the worst insect pest of cabbages in Porto Rico. The small green caterpillers or worms occur in large numbers on the undersides of the leaves, riddling them with holes. These holes do not extend completely through the leaves, so that the leaves have a skeletonized appearance and when blown by the wind they crackle like paper.

This pest is at its worst during the summer months and unless effective measures are used to control it, it is impossible to raise good cabbages.

When full grown, the small caterpillars spin loose silky cocoons on the undersides of the leaves in which they pupate. The adult is a very small grayish moth with patches of white along the borders of the front wings. When the wings are folded, these white areas form the diamond-shaped markings that give the moth its name.

Control.—The leaves of the cabbage should be sprayed on the undersides with arsenate of lead three pounds to fifty gallons of water. A sticker should be added to this spray as the leaves of the cabbage are covered with a waxy secretion. For formula see page 267. If the worms have become abundant before being discovered, the cabbages should be sprayed with a kerosene emulsion spray diluted one to fifteen. For directions for making the emulsion see page 268.

THE SOUTHERN CABBAGE BUTTERFLY (*Pontia monuste*).

This butterfly is usually to be seen flying about patches of cabbages and other cruciferous plants. It deposits clusters of bright yellow eggs on the upper surface of the leaves, and these soon hatch into hairy greenish-yellow caterpillars.

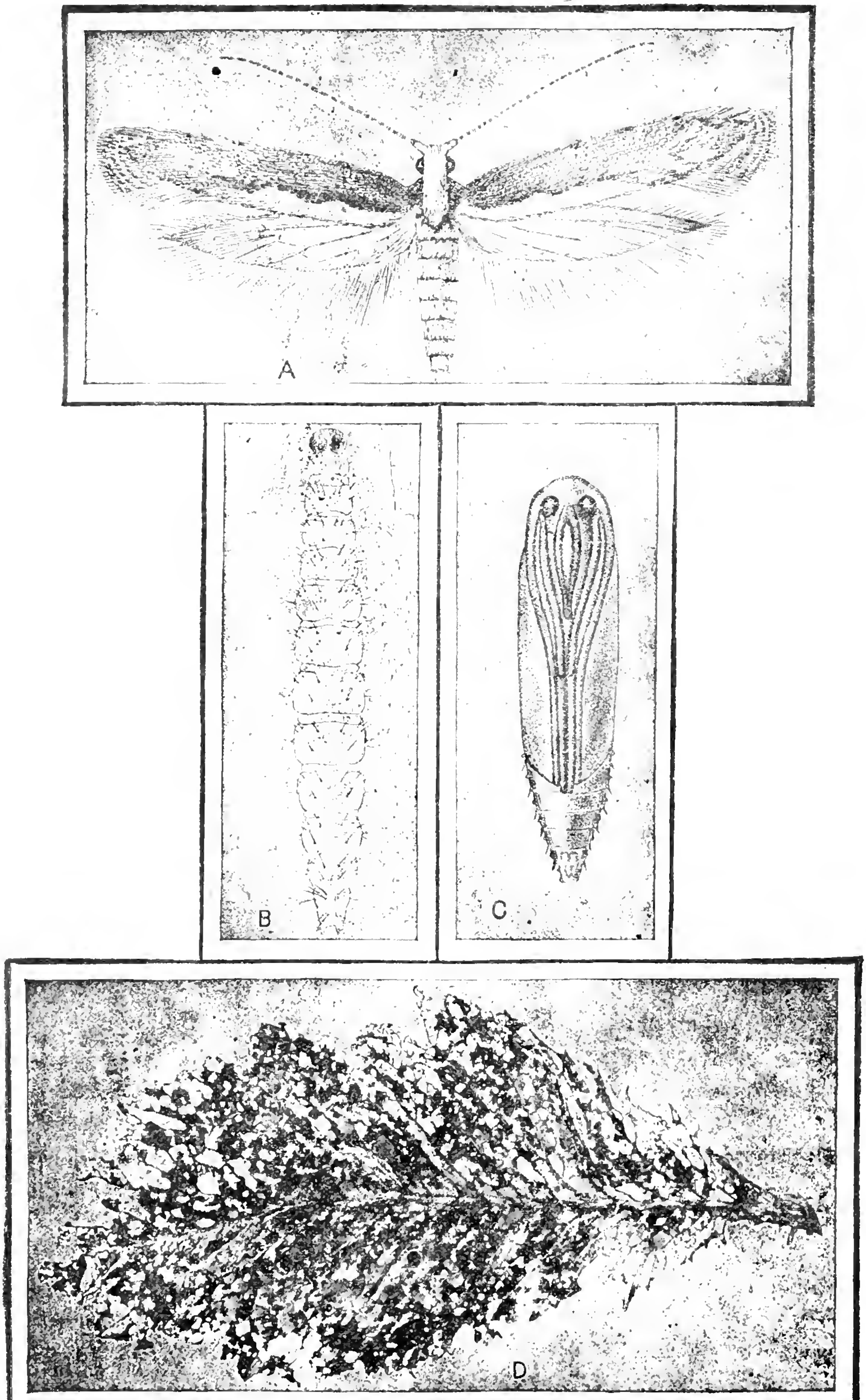

FIG. 36.—The Diamond-Back Moth (*Plutella maculipennis.*) A, adult moth; B, larva; C, pupa; D, mustard leaf showing injury by the larvæ. (U. S. Bureau of Entomology.)

These caterpillars feed ravenously for about two weeks and a half, when they seek a sheltered spot in which to pupate. In a short time they transform into large, handsome, white butterflies, with dark-brown markings on the margins of the wings.

This pest does not do so much damage to the cabbage as it does

FIG. 37.—The Southern White Cabbage Butterfly. (*Pontia Monuste*). Eggs and larva.

to some of the other cruciferous plants. It may be easily controlled with the arsenate-of-lead spray recommended for the preceding species.

THE CABBAGE APHIS (*Aphis brassicæ*).

This aphid or plant louse, although generally controlled by its

parasitic and predaceous enemies, occasionally becomes destructive. It appears at such times in large colonies on the cabbage leaves, sucking the plant juices and distorting the leaves.

The aphid is dusky green in color and appears in winged and wingless forms.

Control.—These lice may be easily destroyed by spraying them with a nicotine sulphate and soap solution. Directions for making this spray may be found on page 268.

OTHER CABBAGE PESTS.

Agromyza sp., mines the leaves; flea-beetles (see General Feeders,

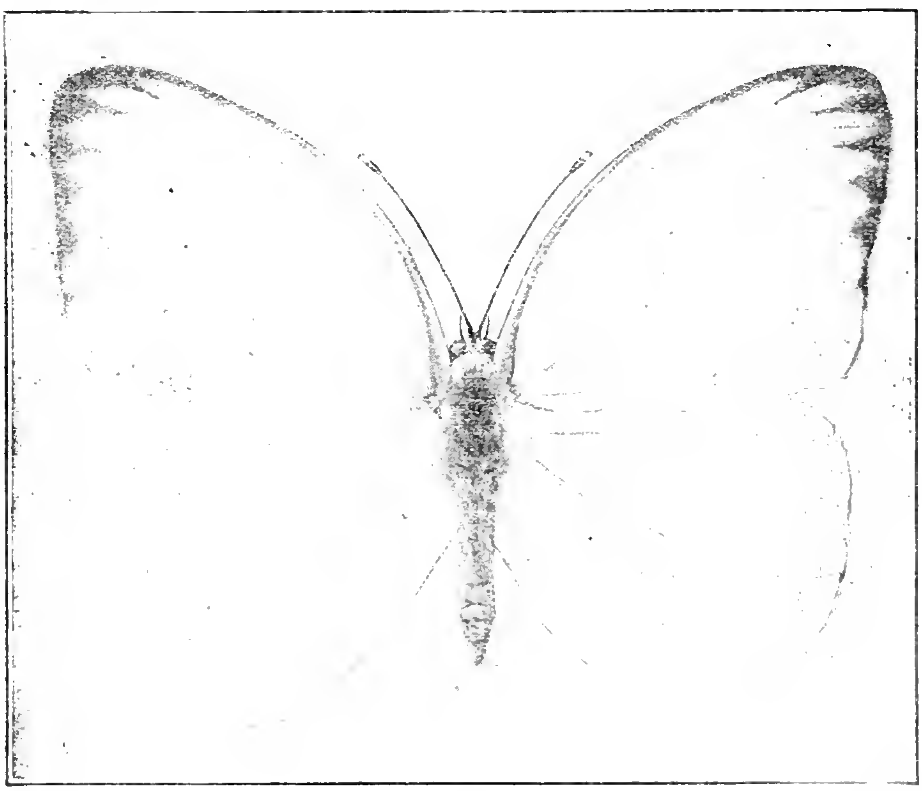

FIG. 38.—The Southern White Cabbage Butterfly (*Pontia Monuste*). Male butterfly. Much enlarged. (U. S. Bureau of Entomology.)

page 271); grasshoppers (see General Feeders, page 272); nematodes (see General Feeders, page 274).

CARROTS.

FLEA-BEETLE (*Systena basalis*).

This flea-beetle is a very general feeder on truck crops. It is very fond of the tender leaves of the carrot and may always be found feeding on it in large numbers.

The female beetle is metallic black in color, with two light spots near the tips of the wing covers, while the male is slightly smaller, and is metallic brown with two longitudinal light bands on the wing covers.

The small yellow eggs are placed in the soil near the roots of the plant, and the slender yellowish white larvæ that hatch from them feed on the tender roots. The entire life cycle covers a period of about two months.

These beetles may be effectively controlled by dusting the plants with a mixture of equal parts of arsenate of lead and hydrated or air-slacked lime or dry leached wood ashes.

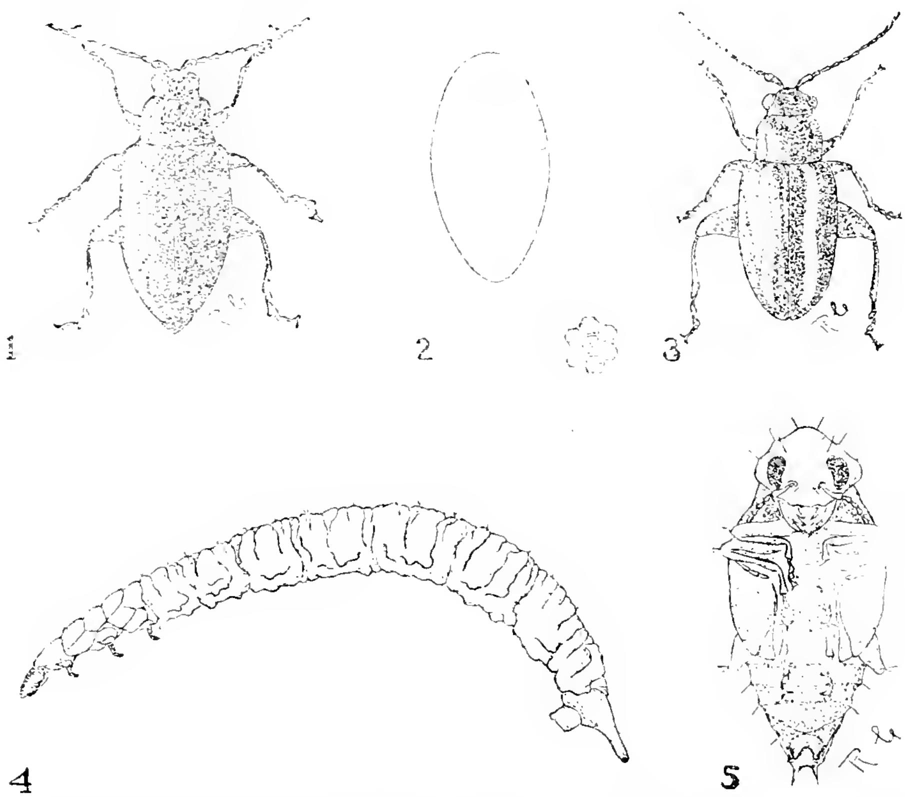

FIG. 39.—Flea-Beetle (*Systena basalis*). 1, adult female; 2, eggs; 3, adult male; 4, full grown larva; 5, pupa. All greatly enlarged.

OTHER CARROT PESTS.

Leaf-hoppers, a great many different species of Jassids, Fulgorids, and Cercopids are always to be found in great abundance feeding on the foliage of the carrot (see General Feeders, page 269).

CELERY.

WOOLY BEAR CATERPILLAR (*Ecpantheria eridanus*).

The hairy brown caterpillars of this arctiid moth do a great deal

of damage to celery by feeding on the tender stalks and leaves.

The female moth deposits several hundreds of greenish-colored eggs in a single mass. These hatch in about a week and the young larvæ swarm over the surrounding foliage. Needless to say such large numbers of these caterpillars do a great deal of damage before they finally pupate and turn into moths some two months later.

The adult moths are large, handsome creatures, with white wings marked with numerous small, dark rings, and with the abdomen orange colored, marked with a few black spots.

Control.—This pest may be controlled by spraying the plants with arsenate of lead, three pounds in fifty gallons of water.

MEALY BUG (*Pseudococcus citri*).

The roots of celery often times become infested with this mealy

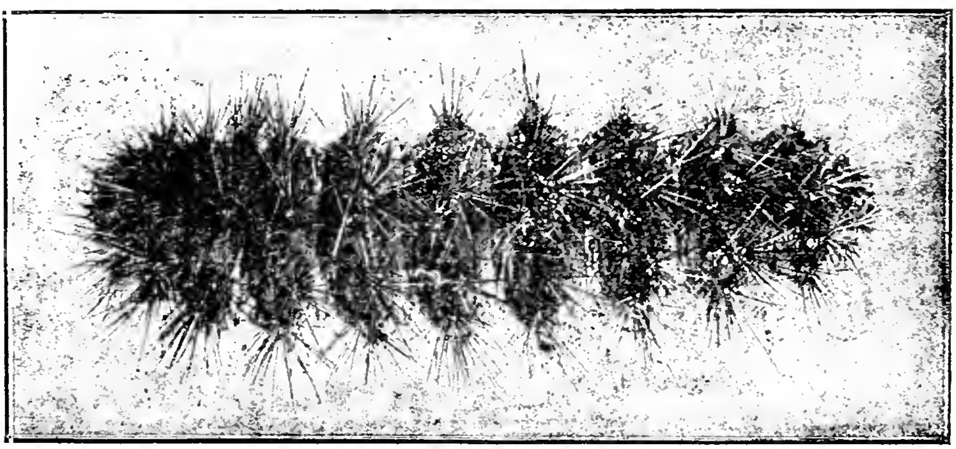

FIG. 40.—Wooly-Bear Caterpillar (*Ecpantheria eridanus*). Larva.

bug. So numerous do they become at times that the plants are stunted and growth is almost entirely checked.

These mealy looking insects (Fig. 41) cause damage by sucking the plant juices through their slender needle-like proboscees. They multiply very rapidly, the females giving birth to hundreds of living young.

Control.—It is very difficult to control this pest, but some relief may be obtained by soaking the soil around the plants with kerosene emulsion, diluted at the rate of one part of stock to ten parts of water. Directions for making the emulsion are given on page 268.

OTHER CELERY PESTS.

Xilomeges sunia (see Chard, page 287); aphids (see Cabbage,

page 281): *Ceroplastes floridensis*, occasionally attacks celery: *Saissetia hemispharica*, (see Eggplant, page 296); nematodes, one of the worst enemies of celery (see General Feeders, page 274).

CHARD.

Xylomeges sunia.

The caterpillar of this moth is extremely destructive to a great

FIG. 41.—Mealy Bug (*Pseudococcus citri*) on roots of celery.

many vegetable crops, but is particularly abundant on chard.

The small, green, dome shaped eggs are laid in clusters of two or three hundred on the leaves, and are covered with a light white

fuzz. They hatch in about four days into caterpillars that when full grown are about an inch and a quarter long. They are dark gray in color, striped on the sides with a broad yellow band, and marked on the back with several velvety black patches.

These caterpillars feed voraciously on the foliage, stripping the tender young leaves to the veins and midrib. At the end of about twelve days they enter the soil to pupate, emerging nine days later as adult moths. The moth has a wing expense of about an inch and a quarter. The front wings and body are a yellowish gray, the hind wings white.

Control.—Spraying the plants with arsenate of lead, three pounds in fifty gallons of water, is an effective method of control.

OTHER CHARD INSECTS.

Pachyzancla bipunctalis does great damage by webbing the leaves (see Beets, page 280); *Zinckenia fascialis* also webs the leaves (see Beets, page 280).

CORN.

THE SOUTHERN GRASSWORM (*Laphygma frugiperda*).

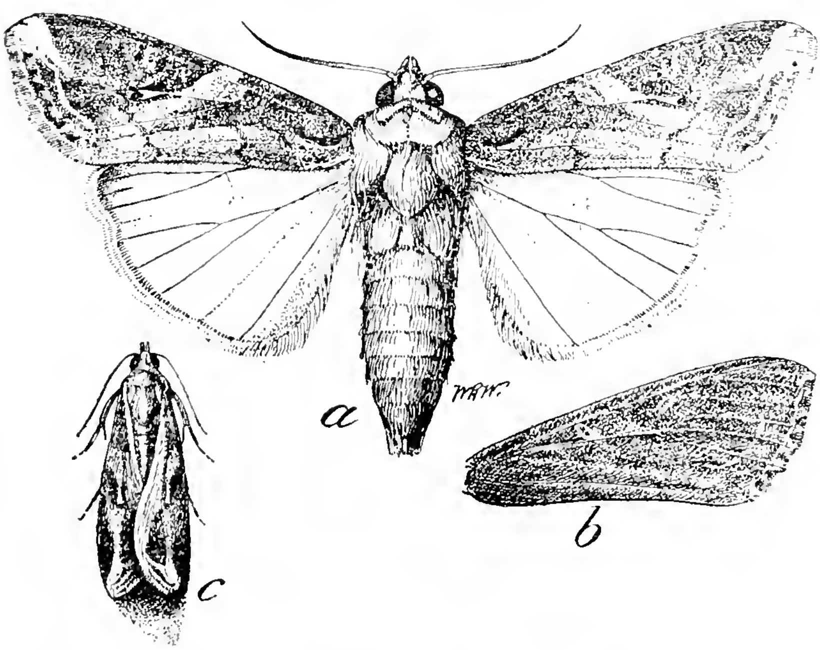

Fig. 42.—The Southern Grassworm (*Laphygma frugiperda*). Moth. (U. S. Bureau of Entomology.)

This insect, known in the United States as the fall army worm, or southern grass worm, is by far the wors[illegible] pest of corn in this country. So a[illegible] is it t[illegible] almost impossible to [illegible] field of [illegible] is free [illegible]. The very de[illegible] larva or worm secretes itself during the day down among the rolled-up leaves of the corn, and at night feeds on the tender, [illegible] folding leaves. Its presence is easily detected by the [illegible] appearance

of the leaves, and the presence of a sawdust-like frass. It also frequently bores into the young ears of corn and destroys them.

The caterpillar when full grown is a little over an inch long. It varies greatly in color, but is usually a light brown, with a broad, wavy, yellow line along the side, and three narrow, yellow stripes along the back. The front of the head is marked with a white inverted Y which serves to distinguish it from larvæ of allied species.

The adult moth also varies considerably in color. One variety has grayish-brown front wings, and shining white hind wings, while the other variety has brownish fore wings ornamented with patches of black, yellow, and other colors, the hind wings being the same as in the first variety.

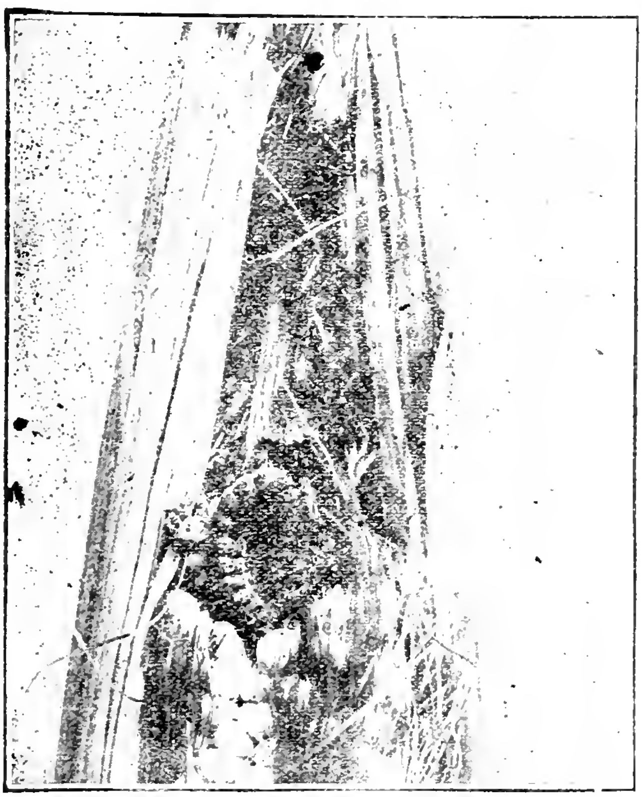

FIG. 13.—Corn Ear Worm (*Heliothis obsoleta*). Larva in situ. (U. S. Bureau of Entomology).

This insect normally breeds on some of the native grasses, but prefers the succulent corn leaves. It is also very fond of many other vegetable plants, and is frequently found boring into the fruit of tomatoes and the green pods of the bean. When numerous, the larvæ have the habit of moving in large bodies from place to place as the food supply grows scanty, to which habit is due the common name of army worm.

Control.—The most effective way of controlling this pest is to dust the plants with a mixture of equal parts of arsenate of lead and hydrated or air-slacked lime, being careful to shake the dust well down among the folded leaves. Another method is to hand-pick the worms.

CORN EAR WORM (*Heliothis obsoleta*).

Another caterpillar that is injurious to the corn is the so-called

corn ear worm. This worm confines its attention chiefly to the ears of the corn.

The yellowish-gray moth lays its eggs usually on the silks of the ears and the young caterpillars on hatching, feed for a short while on the silks, then crawl into the ears where they stay and feed until full grown. They then eat a small hole in the side of the ear, and drop to the soil to pupate, later emerging as adult moths. When the corn is young the eggs are laid on the leaves, and the larvæ develop in the growing bud.

Control.—After the caterpillars have entered the ear it is impossible to reach them with poisons, so it is necessary to kill them before they have made their way within. This may be done by dusting the silks with the poison dust recommended for the preceding species.

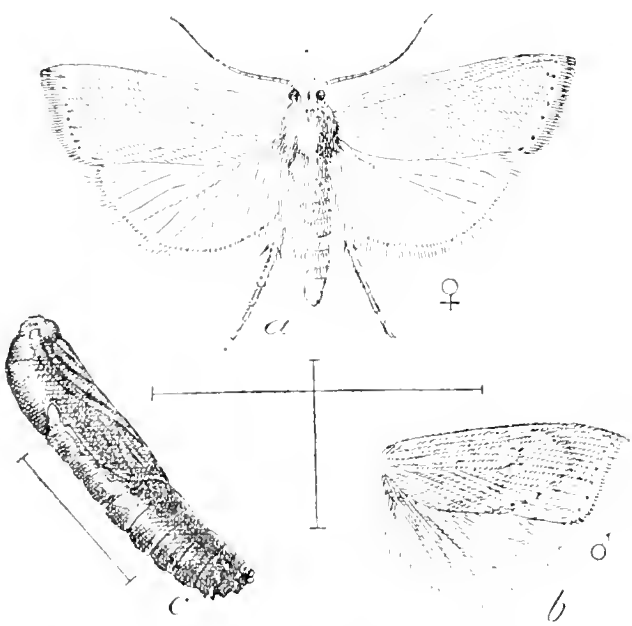

Fig. 44. The Moth Stalk-Borer (*Diatraea saccharalis*). Moth and larva.

THE MOTH STALK-BORER

(*Diatraea saccharalis*).

This destructive insect (Fig. 44), although regarded chiefly as a pest of sugar cane, is very fond of corn and causes great damage to this crop by its feeding activities.

The inconspicuous moth, which varies in color from almost white to a light, yellowish-brown, deposits batches of small, flat, white eggs on the leaves. These hatch in a few days and the young larvæ or caterpillars penetrate the stalk and tunnel through the pith, oftentimes girdling the stalk so that the plant shrivels up and dies, or so weakening it that it is snapped off by the wind. The caterpillar does not confine itself to one tunnel, but often leaves the first one it has made to start another elsewhere.

The full-grown caterpillar is about an inch long, and is a dirty white in color marked with numerous dark spots. It pupates within the burrow that it has formed, and later emerges as a moth through a small hole in the stalk that it cuts before pupating.

Control.—Little can be done to prevent damage by this insect, except to collect the egg clusters and destroy the infested stalks.

CORN LANTERN FLY (*Peregrinus maidis*).

If the base of a corn leaf is examined, the observer will usually find between the leaf sheath and the stalk, a number of peculiar looking insects that sidle quickly around the stalk or hop into the air at being thus disturbed.

These little gray insects with their delicate wings and crescent-shaped heads, are known as lantern flies. The adults are gray in color with darker markings on the wings, while the immature forms are wingless and are somewhat mealy looking. All stages of this insect feed on the plant juices of the corn, sucking it out through the needle-like proboscis. They are always present in more or less abundance, and cause considerable harm by sapping the vitality of the plants.

The adult females insert small, yellow, flask-shaped eggs into the tissue of the leaves and stems, from which hatch young wingless lantern flies. After feeding for about two weeks these finally change into the winged adults.

The amount of damage caused by this insect does not warrant the expense of any special effort to control it on a field scale. However, in a small garden patch they may be controlled by spraying with fish-oil soap solution, one pound of soap in five gallons of water. The addition of five spoonfuls of 40 per cent nicotine sulphate will materially increase the efficiency of this spray.

CORN LEAF APHIS (*Aphis maidis*).

This bluish-green plant louse is occasionally found in great numbers on the upper parts of the stalks and leaves of the corn.

When conditions are favorable, it increases in numbers with great rapidity and injures the leaves by sucking the juices and causing them to shrivel up and die.

The young or immature forms are wingless and resemble the adults which may be either winged or wingless.

Control.—So numerous are the insect enemies of this plant louse that its spread is checked soon after it appears, hence no artificial remedies are required.

CORN FEEDING SYRPHID FLY (*Toxomerus politus*).

This species is occasionally very abundant on corn and some of the native wild grasses. The yellowish colored grubs feed on the pollen grains and on the saccharine cells in the axils of the leaves.

This habit of eating the pollen, while not usually serious, might at times interfere with the pollination of the corn.

The grubs pupate between the stalk and the leaf-sheath, or on any convenient portion of the leaf, and emerge as small yellowish flies spotted and banded lightly with black.

Control.—Fortunately the parasitic enemies of this insect are so numerous that it never causes serious damage, and no artificial remedies are required.

CORN LEAF MINERS (*Agromyza parvicornis and Cerodonta dorsalis*).

The leaves of the corn are frequently mined by the larvæ or grubs of these two flies. The adult flies insert their small white eggs in the tissue of the leaf and the young grubs burrow their way towards the base of the leaves, devouring the tissue between the two leaf surfaces.

The grub of *Cerodonta dorsalis* makes a long, narrow burrow or mine and may occasionally leave the first mine and start another, but that of *Agromyza parvicornis* remains in the first mine, forming a long, narrow mine that finally spreads out into a small blotch.

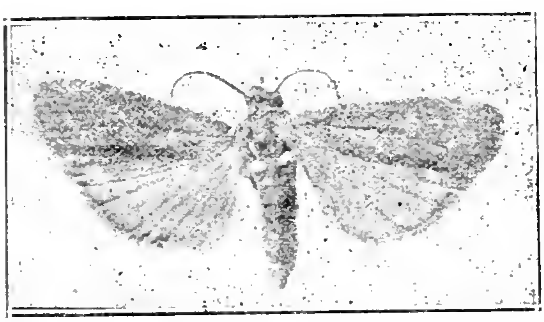

FIG. 45.—Cowpea Stalk and Pod Borer (*Balloria cistipennis*). Adult.

Control.—As in the case of the preceding species these two insects also have so many insect enemies that prey upon them that they never becomes sufficiently numerous to cause serious damage.

OTHER CORN PESTS.

Aphis sp., feeds on roots; *Diabrotica graminea*, the larvæ feed on the roots and the adults on the tassels (see Okra, page 302); *Pseudococcus* sp., on roots.

COWPEAS.

STALK AND POD BORER (*Balloria cistipennis*).

The larva of this small moth does considerable damage at times by boring in the stalks and pods of the cowpea.

The presence of this caterpillar is indicated by a quantity of

frass exuding from the entrance hole in the stem or pod. If the stem be split lengthwise, the small dirty-white or brownish caterpillar will be discovered at the end of the burrow that it has made. The injury to the stalk usually causes the top of the plant to wither and die, while the peas in the infested pods are usually rendered worthless.

The adult is a small moth with dark-brown front wings and creamy white, shining hind wings.

Control.—Little can be done except to collect and destroy infested plants and pods.

THE VELVET BEAN CATERPILLAR (*Anticarsia gemmatilis*).

This insect which is so destructive to the velvet bean also attacks the cowpea.

The slender green caterpillars are marked with a few indistinct light lines, running lengthwise of the body, but so well do they blend with the foliage that it is very difficult to see them. When disturbed they throw themselves about violently by vigorous contortions of the body, a method of escape that is very effective.

When full grown the larva enters the soil to pupate and later emerges as a fairly large grayish-brown moth, with a dark line extending diagonally across each wing.

Control.—The caterpillars may be controlled by dusting the plants with a mixture of one part of arsenate of lead to three or four parts of hydrated or air-slacked lime or dry, leached wood ashes.

COWPEA POD WEEVIL (*Chalcodermus æneus*).

This small black weevil may occasionally be seen feeding on the leaves and pods of the cowpea.

The female beetles lay their eggs within the seeds in the pod and the young grubs develop within the peas until they attain their full growth. They then cut their way through the side of the pods and make their way to the ground, where they pupate and later emerge as adult beetles. They never become numerous enough to cause serious damage.

OTHER COWPEA PESTS.

Cerotoma ruficornis is one of the worst pests of cowpeas. The beetles strip the leaves, and the larvæ feed on the roots (see Beans,

page 275 ; *Eudamus proteus* (see Beans, page 277); *Nacoleia indicata* (see Beans, page 278); weevils (see Beans, page 279).

CUCUMBERS.

THE MELON CATERPILLAR (*Diaphania hyalinita*).

Cucumber, melon, and squash vines are often seriously injured by a small, slender green worm known as the melon caterpillar. This worm or caterpillar has the habit of feeding on the foliage, and also of boring into the fruit and stalks of the vine.

After feeding for about two weeks, the caterpillar transforms to a pupa within a fold of a leaf. A few days later the adult moth emerges. It is a very handsome moth, with iridescent white wings bordered with brown.

It may be controlled by spraying the plants with arsenate of lead, three pounds in fifty gallons of water, or by dusting them with a mixture of equal parts of arsenate of lead and hydrated or air-slacked lime.

FIG. 46.—The Melon Caterpillar (*Diaphania hyalinita*). Adult Moth.

MELON APHIS (*Aphis gossypii*).

During certain seasons of the year, the leaves of the cucumber and other cucurbits will be seen to be curled up and wilting, and if they are examined it will be seen that the undersides of the leaves are covered with masses of greenish plant lice.

These winged and wingless soft-bodied insects are known as melon aphides and they increase with such rapidity that they very often ruin whole patches of vines before they are brought under control by their natural enemies. They injure the plants by sucking the vital juices. As soon as one leaf is dried up they move to another.

Control.—These plant lice may be easily controlled by spraying them with a nicotine sulphate and soap solution as recommended on page 268.

THE LARGE STRIPED CUCUMBER BEETLE (*Diabrotica innuba*).

These black and yellow striped beetles are always to be seen around cucumber, squash, and melon vines. They feed chiefly on the flowers,

which they are very fond of, but occasionally eat the tender young leaves.

The beetles lay their small yellow eggs in the soil around the roots of the plants, and the larvæ, which are slender, white, worm-like creatures, feed on and tunnel the roots.

These beetles, although always common, never become excessively abundant, probably due to the fact that cucurbits are never grown on a very large scale in Porto Rico.

Control.—When these beetles are troublesome the plants should

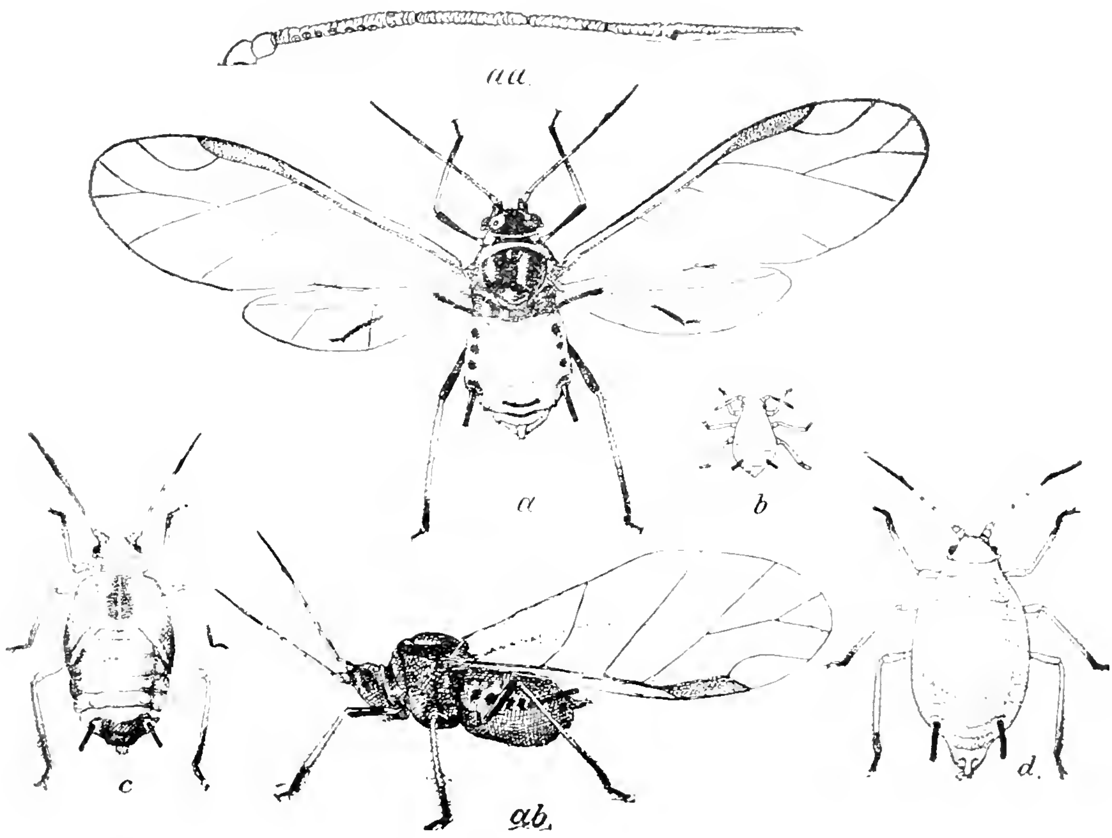

FIG. 47.—Melon Aphis (*Aphis gossypii*). *a*, winged female; *ab*, dark female; *b*, young nymph or larva; *c*, last stage of nymph; *d*, wingless female. All much enlarged. (U. S. Bureau of Entomology.)

be sprayed with arsenate of lead, three pounds in fifty gallons of water. This will repel the beetles and kill those that feed.

THE SMALL STRIPED CUCUMBER BEETLE (*Diabrotica bivitatta*).

This beetle is very similiar to the preceding species except that it is smaller and its legs are entirely testaceous, whereas the legs of the larger species are partly black.

Its life history and feeding habits are very similiar to the preceding form, and it may be controlled in a similar manner.

OTHER CUCUMBER PESTS.

Ants eat out the contents of seeds (see General Feeders, page 269); *Leptoglossus gonogara* (see Squash, page 307); *Phthia picta* (see Squash, page 307); *Pycnoderes incurvus* (see Squash, page 306).

EGGPLANT.

Fig. 48.—Melon Aphis (*Aphis gossypii*). Cantaloupe leaves showing curling caused by the aphis. (U. S. Bureau of Entomology.)

FIRE ANT

(*Solenopsis geminata*).

This abundant and disagreeable ant has been occasionally found doing damage to the eggplant. It builds galleries of mud over the stem and branches and covers the fruit with a layer of soil, under which it feeds.

It may be controlled by destroying the nests that are to be found at or near the roots of the plant affected. For directions see page 269.

EGGPLANT APHIS

(*Rhopalosiphum persicæ*).

This grayish-green aphid frequently occurs in great numbers on the eggplant and peppers. Both winged and wingless forms occur on the plants at one time, and they multiply so rapidly that once started they soon infest every plant in the patch.

They feed chiefly on the undersides of the leaves, but often occur on the upper sides and on the young developing buds as well.

Control.—Spray the infested plants with a nicotine-sulphate and soap solution as recommended on page 268.

EGGPLANT LACE BUG (*Corythaica monacha*).

This insect is undoubtedly the worst insect pest of the eggplant in this country. It is a delicate little insect with gray, lace-like wings marked with brown.

It deposits small flask-shaped eggs in the tissue of the leaves,

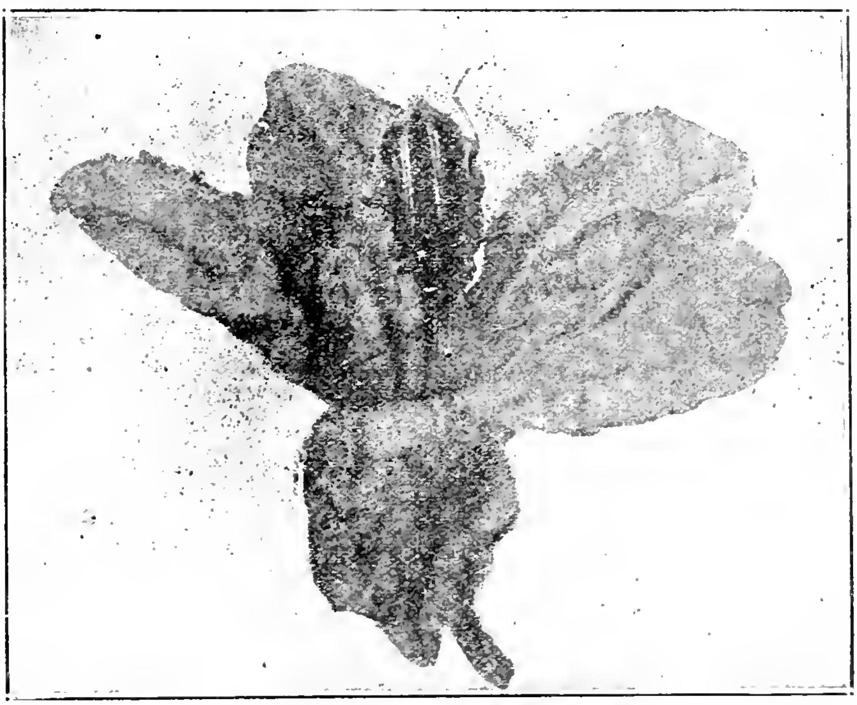

FIG. 89.—The Large Striped Cucumber Beetle (*Diabrotica innuba*). Adult on cucumber blossom.

which hatch into small wingless nymphs. These, together with the adults, congregate in hundreds on the undersides of the leaves of the eggplant, sucking out the plant juices and causing the leaves to dry up and fall off.

The nymphs attain adult form in about ten days after hatching, a rapidity of development that allows them to increase in numbers so rapidly that unless they are controlled they may completely defoliate an entire patch.

Control.—They may be controlled with a soap and water spray, eight pounds of fish-oil soap to fifty gallons of water. Care should

be taken to spray the undersides of the leaves as it is essential to hit the lace bugs in order to kill them.

TOBACCO FLEA-BEETLE (*Epitrix parvula*).

This small brown beetle (Fig. 52) commonly occurs in large numbers on the eggplant.

In addition to the damage it causes by riddling the leaves with its feeding punctures, it is thought to spread from one plant to another a disease[1] that is very destructive to the eggplant.

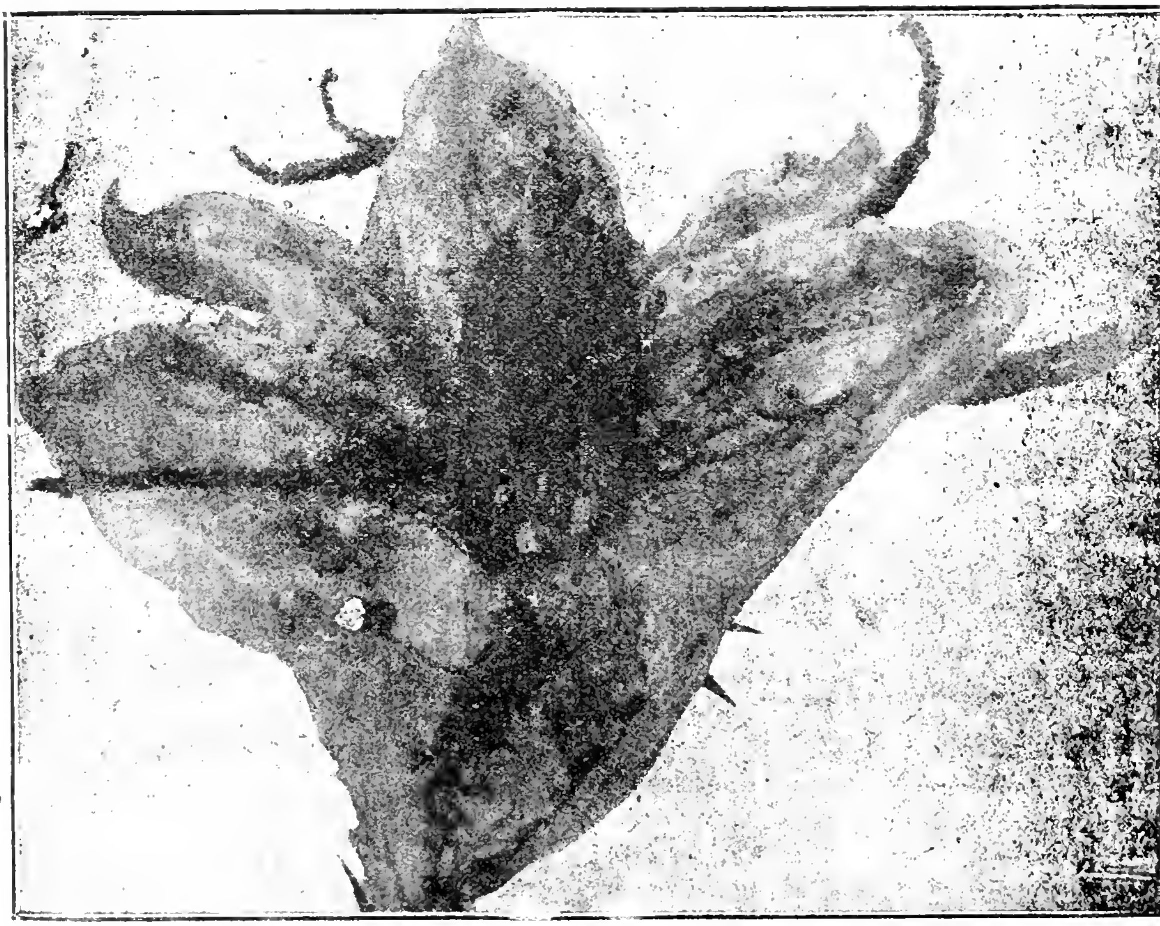

FIG. 50.—Eggplant Aphis (*Rhopalosiphum persicæ*). Aphid on blossom of eggplant.

The minute oval eggs of this insect are laid in the soil around the roots, and the small threadlike white larvæ that hatch from them feed on the roots.

Control.—This beetle may be effectively controlled by dusting the plants with a mixture of equal parts of arsenate of lead and hydrated or air-slacked lime or dry, leached wood ashes.

[1] Wilt, due to *Bacterium solanacearum*.

LEAF FOLDER (*Pachyzancla periusalis*).

The larvæ of this pyralid moth fold over the edges of the leaves of the eggplant, forming a retreat in which they live and feed. They attack the plants chiefly when they are young and tender, rarely causing serious damage after the plants have attained their growth.

The moth is gray in color with a wing expanse of about three-fourths of an inch, the wings being marked with transverse, dark, wavy lines. They deposit small, flat, translucent eggs singly on the leaves which hatch in a few days into the caterpillars that do the damage.

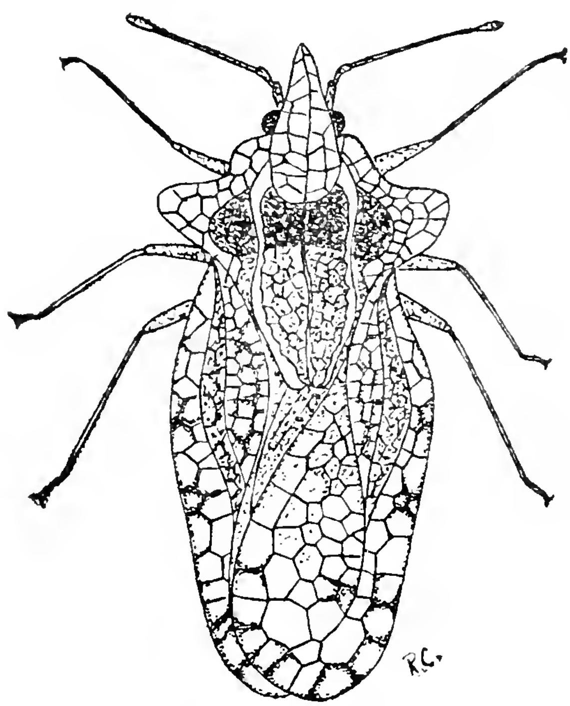

FIG. 51.—Eggplant Lace Bug (*Corythaica monacha*). Adult.

The caterpillars when full grown are about three-fourths of an inch long, and are yellowish-white in color with light reddish-brown markings.

Control.—Spraying the plants with arsenate of lead, three pounds in fifty gallons of water or dusting them with a mixture of equal parts of arsenate of lead and hydrated or air-slacked lime, will effectively protect them from this insect.

TOBACCO SPLIT WORM

(*Phthorimaea operculella*

The tobacco split worm, so called on account of its injury to tobacco, is the caterpillar of a small inconspicuous gray moth. It causes considerable damage by mining the leaves of the eggplant, causing them to dry up and so seriously weakening the plant.

The small oval eggs of this species are laid singly on the leaves, and the caterpillar which is greenish in color, tinged with maroon on the thorax, usually begins to tunnel the midrib of the leaf, then branches out and mines the membrane of the leaf. When disturbed the caterpillar retreats to its tunnel in the midrib.

Control.—The affected leaves should be collected and destroyed, or the caterpillars should be destroyed in the mines by pinching.

EGGPLANT LEAF MINER (*Acrocercops sanctæcrusis*).

The leaves of the eggplant are also mined by another caterpillar, a small, red caterpillar that makes a small, somewhat blotch-shaped mine and causes a peculiar puckering of the leaf around the mine. They often occur in numbers in the same leaf, and are easily distinguished from the preceding species which makes a much longer mine.

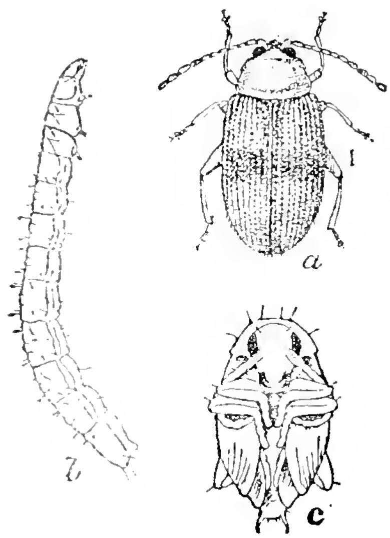

FIG. 52.—Tobacco Flea-Bee- adult; *b*, larva; *c*, pupa. tle (*Epitrix parvula*). *a* (U. S. Bureau of Ento- mology.)

The adult is a very small moth with brownish front-wings banded with white, and feathery, brown hind-wings.

Control.—The parasites of this insect are very abundant and keep it well under control at all times.

THE EGGPLANT STEM BORER

(*Baris torquatus*).

This weevil is a pest of both the wild and cultivated eggplant. The adult beetle, which is a small black-and-white marked weevil, feeds to some extent upon the foliage, while the grub-like larva bores in the stem and branches of the eggplant, sometimes causing its death.

The beetle lays its small, oval, white eggs in a crescentic slit in the stem and in a few days these hatch into small, white, legless grubs that begin at once to bore in the stem.

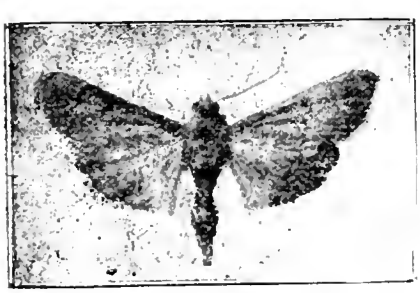

FIG. 53.—Leaf Folder (*Pachyzancla periusalis.*) Adult.

Control.—Affected branches should be collected and destroyed. The adult beetles may be hand picked.

EGGPLANT BUD WEEVIL

(*Anthonomus pulicarius*).

The eggplant is also attacked by another weevil that feeds on the leaves and breeds in the flower buds.

The eggs of this species are laid in the young developing buds, and the small white legless larvæ develop within the bud, causing it to dry up and drop off. Several grubs may develop in one flower

bud. The adult beetle is a small, dark-gray, long-snouted weevil.

Control.—The beetles should be hand picked and the affected buds gathered and destroyed.

HEMISPHERICAL SCALE (*Saissetia hemispharica*).

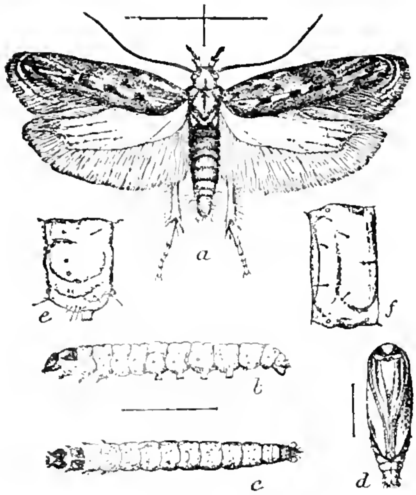

FIG. 54.—Tobacco Split Worm (*Phthomeria apercudella*). *a*, moth; *b*, larva; *c*, larva; *d*, pupa. (U. S. Bureau of Entomology.)

This brown hemispherical scale occurs on a very wide range of host plants, among which is the eggplant. It sometimes occurs in such numbers as to completely cover the stems and branches of this plant.

The insect that lives under this brown shell-like covering, sucks the juices of the plant, and when it occurs in such numbers as mentioned above, soon kills the host.

Control.—This scale may be destroyed by spraying the plants with kerosene emulsion, one part of stock solution in fifteen parts of water. Directions for making the stock solution are given on page 268.

THE WHITE SCALE (*Hemichionaspis minor*).

This small flaky white scale also attacks the stems and branches of the eggplant, but it is usually not nearly so abundant and causes far less damage than the preceding species. It may be controlled in a similiar manner.

FIG. 55.—The Eggplant Stem Borer (*Baris torquatus*). Adult beetle.

OTHER EGGPLANT INSECTS.

Changa (see General Feeders, page 270); *Diabrotica graminea*, feeds on flowers (see Okra, page 302); *Epitrix cucumeris* (see Tomatoes, page 310); grasshoppers (see General Feeders, page 272); *Laphygma frugiperda*, feeds on foliage and fruit (see Corn, page 288); *Systena basalis* (see Carrots, page 284).

LETTUCE.

Nacoleia indicata webs and feeds on the leaves (see Beans, page 278)

MELONS.

This crop is attacked by the same insects that attack the cucumber and squash.

CHINESE MUSTARD.

POD BORER.

The larva of this small moth damages the mustard by boring in the seed pods and destroying the seeds.

It is a small, slender, white caterpillar, striped on the back with five longitudinal brown lines. Head and prothoracic plate a brownish black.

The moth is a light gray in color; the front wings white, banded profusely with transverse, wavy, brownish-gray bands; hind wings white, margined with gray.

Control.—Infested seed pods should be collected and destroyed.

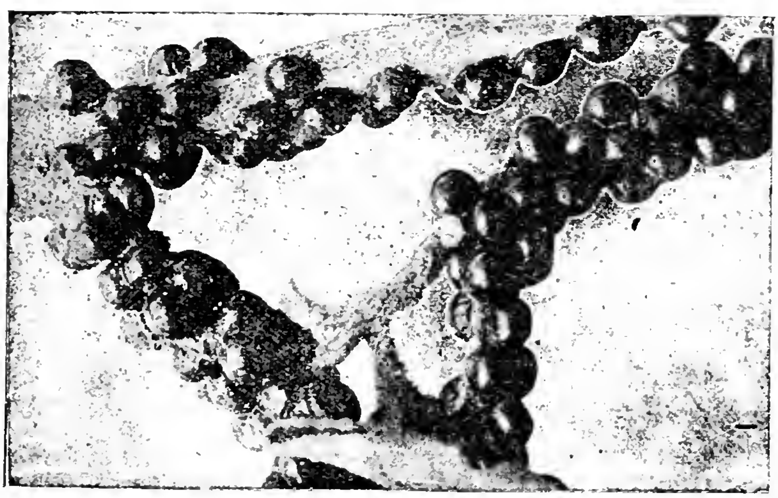

FIG. 56.—The Hemispherical Scale (*Saissetia hemisphærica*) on eggplant. (U. S. Bureau of Entomology.)

OTHER MUSTARD PESTS.

The mustard is attacked by the same insects as the cabbage (see page 281).

OKRA.

THE GREEN DIABROTICA (*Diabrotica graminea*).

This green beetle is one of the most numerous of our garden insects. It attacks almost all vegetable crops, and is particularly fond of the flowers. It is very abundant on okra, feeding on the petals, pollen, and pistil of the flowers and seriously interfering with pollination.

The beetle lays small white eggs in the soil, and the slender white larvæ feed on the roots of a number of plants.

Control.—The beetles may be controlled by spraying the plants with arsenate of lead, three pounds in fifty gallons of water.

OTHER OKRA PESTS.

Aulacaspis pentagona, the West Indian peach scale, occasionally attacks the stalks and branches; fire ant, feeds on the flowers and young growth (see Eggplant, page 296); plant lice occur on the undersides of the leaves (for control see Cabbage Plant louse, page 283).

ONION.

THE ONION THRIPS (*Thrips tabaci*).

The drying up and withering of the tips of the onion leaves, so commonly seen in onion patches, is caused chiefly by the activities of this little insect called the onion thrips.

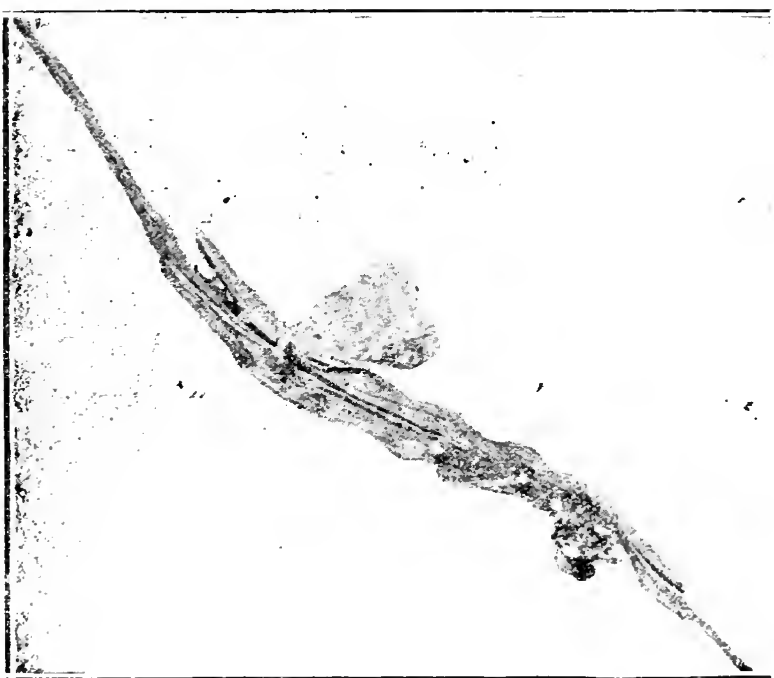

FIG. 57.—Mustard Pod Borer. Adult moth and larva on pod.

It is one of the most destructive of the vegetable-feeding thrips and attacks a wide variety of plants. The adult insect is a slender elongate little creature, about one twenty-fifth of an inch long, and is provided with two pairs of delicate wings fringed with hairs. It is pale yellow in color.

This insect causes damage by rasping or chafing the leaf surface, causing the affected portion to die and shrivel up.

The very minute eggs are inserted singly within the leaf tissue and hatch in about four days. The young are wingless and almost transparent at first, but later change to a greenish-yellow. They feed together in groups, and pass through a number of changes in form before becoming adults.

Control.—These thrips are rather difficult to control owing to the difficulty of hitting them with a spray solution. Good results may

be obtained, however, by spraying with a nicotine sulphate and soap solution as recommended on page 268, or with kerosene emulsion diluted one to fifteen.

OTHER ONION PESTS.

Laphygma frugiperda (see Corn, page 288).

FIG. 58.—The Green Diabrotica (*Diabrotica graminea*). Adult beetle on blossom of okra.

PEAS.

RED SPIDER (*Tetranychus quinquenuchus*).

In dry seasons the vines of the green or garden pea are often attacked by a small red-colored mite known as red spider.

These small mites breed very rapidly, and once started soon cover a vine. In feeding they cause the leaves to turn yellow and dry up.

The adults are minute rounded creatures, provided with eight legs. They are a deep red in color.

The eggs are laid on the leaf and hatch in a few days. The young are similiar in form to the adults except that they have only six legs.

These mites are readily destroyed by spraying the plants with lime sulphur, one part in seventy-five parts of water, or by dusting the plants with flowers of sulphur diluted one-third with road dust or air-slacked lime.

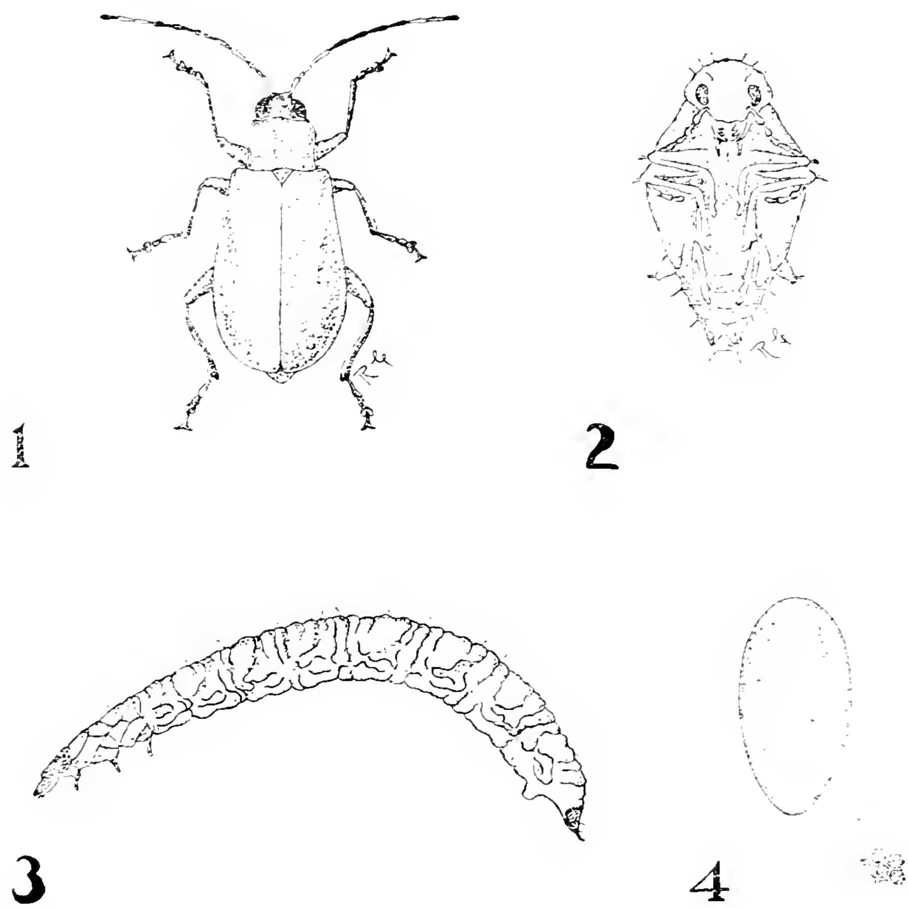

FIG. 59.—The Green Diabrotica (*Diabrotica graminea*). 1, adult; 2, pupa; 3, larva; 4, eggs.

PEA THRIPS.

These thrips, which are slender, white creatures, are often found in company with the red spiders. They cause a somewhat similiar injury. Their life history is very similiar to that of the onion thrips, and they may be controlled in a similar manner (see Onion, page 303).

OTHER PEA PESTS.

Leptoglossus gonogara sucks the juice from the pods, (see Squash.

page 307); *Nacoleia indicata* (see Beans, page 278); *Xylomeges sunia* (see Chard, page 287).

PEPPERS.

Aphis, *Rhopalosiphum persica* (see Eggplant, page 296); *Amphiacusta caribbea* or sick cricket, (see General Feeders, page 270); *Hemichionaspis minor* (see Eggplant, page 301); lapas (see Genneral Feeders, page 274); *Laphygma frugiperda* (see Corn, page 288).

RADISH.

The radish is attacked by the following pests: *Pontia monuste* (see Cabbage, page 281); leaf miner, *Agromyza* sp.; flea-beetles (see General Feeders, page 269).

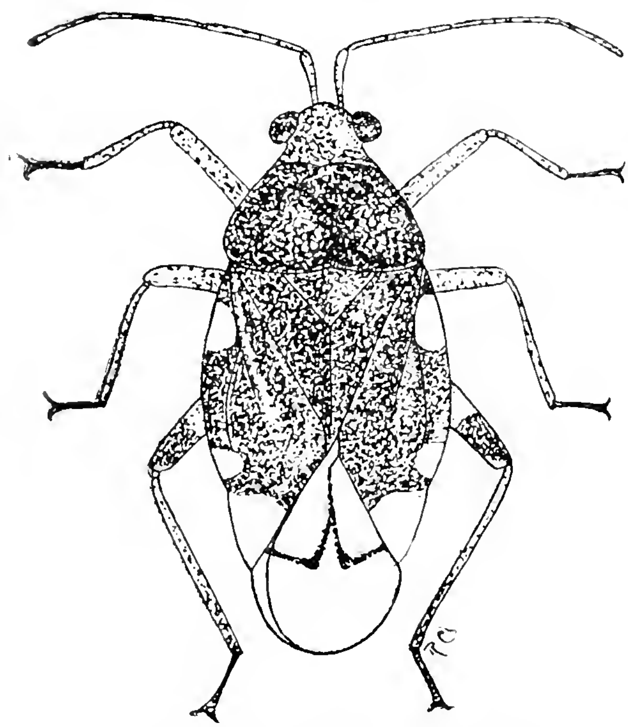

FIG. 60.—Small Black Squash Bug (*Pycnoderes incurvus*). Adult.

SQUASH.

SMALL BLACK SQUASH BUG

(*Pycnoderes incurvus*).

This peculiar-looking black bug feeds in all its stages on the squash and melon vines. It sucks the juice from the leaves, giving them a speckled appearance at first, but later causing them to dry up and die.

The small, translucent, flask-shaped eggs are inserted in the tissue of the stems and large veins of the leaves, and hatch in a few days into small, wingless, greenish-white nymphs. These wingless nymphs feed on the undersides of the leaves for about two weeks, growing in size and moulting five times before appearing as adults. They retain their greenish-white color until they become adults, then change to a deep black.

They may be controlled by spraying the undersides of the leaves with a nicotine-sulphate and soap solution as recommended on page

268. It is well to bear in mind that it is necessary to hit this insect with the spray in order to kill it.

LARGE SQUASH BUG (*Leptoglossus gonogara*).

This large, brownish-black bug is very commonly found with its long, needle-like proboscis inserted in the stems of the squash vine.

It lays small, brown, barrel-shaped eggs in a single row on the stems of the vine. These hatch into small, bright-red and black wingless nymphs that suck the juices from the leaves and stems in a similiar manner to the adult. These nymphs pass through a number of forms and color changes before finally becoming adults.

Control.—The best method of controlling this pest is to hand pick the adults and spray the nymphs with a nicotine sulphate and soap solution, prepared as recommended on page 268.

FIG. 61.—Large Squash Bug (*Leptoglossus gonogara*). Adult.

OTHER SQUASH PESTS.

Phthia picta (see Tomatoes, page 311). The squash is also subject to the attack of all insects that affect the cucumber (see page 294).

SWEET POTATOES.

MOTTLED TORTOISE BEETLE (*Coptocycla signifera*).

Sweet potatoes are sometimes attacked by a beautifully colored beetle called the mottled tortoise beetle. This beetle, as the name implies, is shaped somewhat like a turtle. It is black in color, and marked with six irregular golden spots.

The native food plant of this beetle is the wild morning glory, but it leaves it for the sweet potatoes, riddling the leaves with its feeding punctures. The peculiar-shaped, yellowish larvæ also feed on the leaves but do not cause nearly so much damage as do the beetles.

Control.—This pest may be controlled by spraying the plants with arsenate of lead three pounds in fifty gallons of water.

Chelymorpha argus var. *geniculata.*

The sweet potato is also attacked by another tortoise beetle. It is much larger than the preceding species, and is a brick red in color, marked with numerous black dots.

Its habits are very similiar to the preceding species, and it may be controlled by similiar means.

SWEET POTATO FLEA-BEETLE (*Chaetocnema apricaria*).

This minute bronze-green flea-beetle, which usually lives on the wild morning glory, is very fond of the sweet potato foliage, and often causes injury by its feeding activities.

It may be controlled by dusting the plants with a mixture of equal parts of arsenate of lead and air-slacked lime or dry, leached wood ashes; or by spraying the plants with arsenate of lead three pounds in fifty gallons of water.

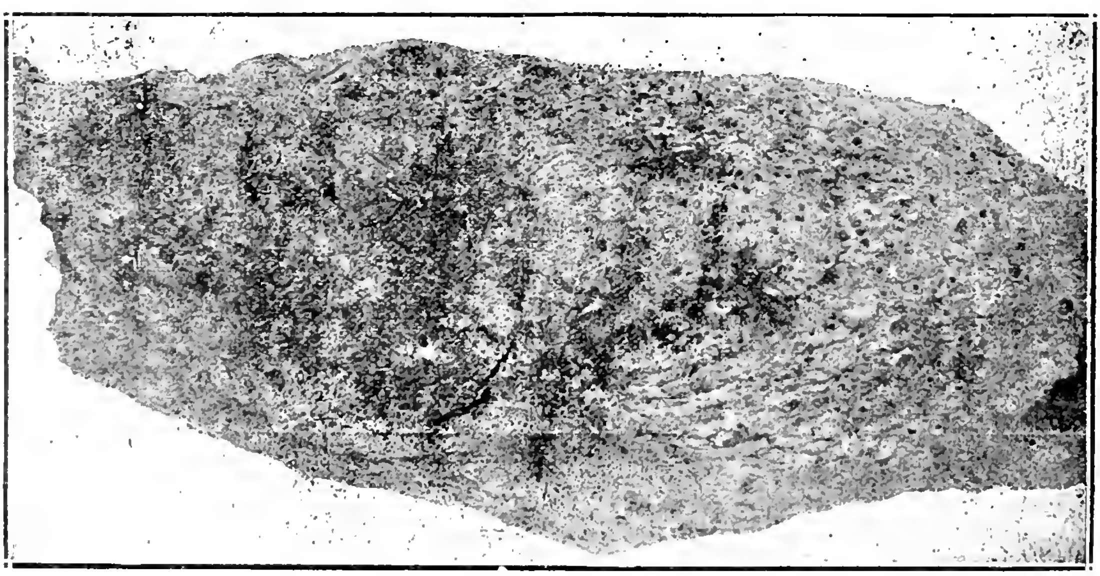

FIG. 62.—Sweet Potato Root Borer (*Cylas formicarius*). Adults on sweet potato.

THE SWEET POTATO ROOT-BORER (*Cylas formicarius*).

The sweet potato root-borer is a slender beetle about one-fourth inch long and bluish black in color, except the thorax and legs which are rufous.

The eggs are deposited in small cavities hollowed out of the stem of the potato plant. Small white grubs hatch from these and burrow

down the stalks to the roots, finally pupating and transforming to beetles at the end of the burrow.

After this first generation the beetles continue breeding in the roots, and as the complete life cycle consumes only a moth, the potatoes are soon riddled with burrows and rendered unfit for use. Owing to the practice of leaving the crop in the ground for a long period of time, a mild infestation soon spreads over the entire field.

Control.—In fighting this pest the best methods are preventive ones. Clean seed or cuttings should be used and they should not be planted in land known to have been infested with the weevil the previous year. Infested potatoes should be fed to livestock.

SWEET POTATO SCARABEE (*Euscepes batatæ*).

Another weevil that injures the sweet potato is the so-called "scarabee," a small grayish-black, snout beetle. It is somewhat similiar in habits to the preceding species, spending its entire life cycle of thirty days in or on the roots.

Control.—Control methods are the same as for the preceding species.

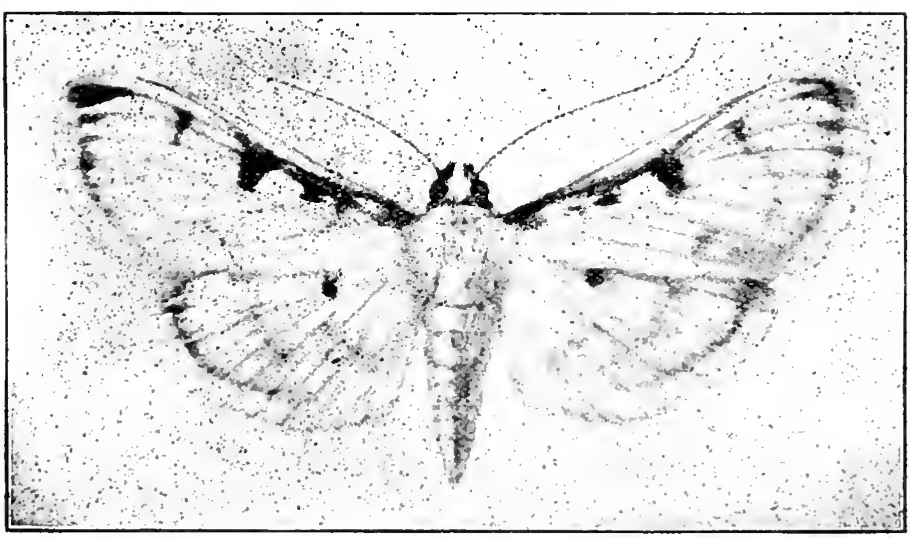

FIG. 63.—Sweet Potato Webworm (*Pilocrocis tripunctata*). Moth. Enlarged. (U. S. Bureau of Entomology.)

SWEET POTATO WEBWORM (*Pilocrocis tripunctata*).

The pale green larvæ of this moth feed on the sweet potato foliage, webbing the leaves together to form a shelter in which they live.

The adult moth is light yellow in color, with black and brown markings on the wings.

Control.—An arsenate of lead spray, three pounds in fifty gallons of water will effectually control this pest.

SWEET POTATO BUG (*Spartocera fusca*).

This large, dull-brown colored bug feeds in all its stages on the sweet potato. The nymphs and adults insert their beaks into the stems of the vine and suck the juice.

Control.—The adults should be hand picked, but the nymphs should be sprayed with kerosene emulsion diluted one to fifteen. Directions for making the emulsion are given on page 268.

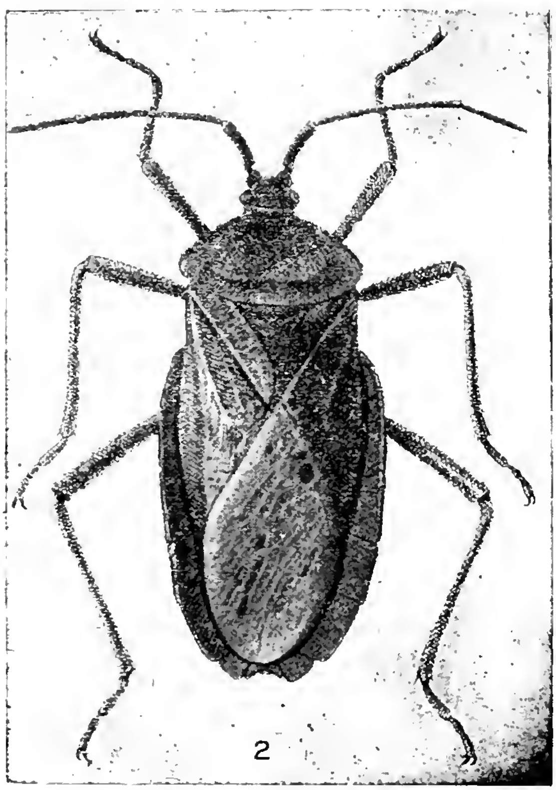

FIG. 64.—Sweet Potato Bug (*Spartocera fusca*). Adult. Greatly enlarged. (U. S. Bureau of Entomology.)

OTHER SWEET POTATO PESTS.

Empoasca mali is at all times abundant (see Beans, page 276); *Systena basalis* (see Carrots, page 284).

TOMATO.

Epitrix cucumeris.

This little black flea-beetle, known in the United States as the potato flea-beetle, occurs very commonly on the tomato, prefering it to any of the other truck crops.

It injures the plant by riddling the leaves with its feeding punctures, and in addition is thought to spread a serious disease [1] of the tomato.

The small, white eggs are laid in the soil, and the minute thread-like larvæ feed on the roots. The entire life cycle is completed in about a month and a half.

Control.—The beetles may be successfully controlled by dusting the plants with a mixture of equal parts of arsenate of lead and air-slacked lime or dry, leached wood ashes.

THE HORNWORM (*Phlegethontius sexta*).

The larva of this sphinx moth is easily recognized by its large

[1] Wilt (*Bacterium solanacearum*).

size and peculiar horn-like process at the end of the body. It is a voracious eater, consuming enormous quantities of foliage.

The adult moth is a large heavy-bodied insect, with a wing expanse of about four inches. Its wings are a dull, dark, brownish-gray, while the segments of the abdomen are strikingly marked with yellow.

The moths begin to fly at dusk, feeding on the nectar of the flowers, and laying large greenish eggs singly on the foliage of the tomato and other food plants.

The eggs hatch in a few days into small, green caterpillars, that feed and develop until when full grown they are three or four inches long. They are green in color, with white stripes along the sides.

Control.—Both eggs and larvæ are rather heavily parasitized, so the larvæ never become very numerous. They may usually be controlled by hand picking, but if too numerous for that an application of arsenate of lead three pounds in fifty gallons of water is very effective.

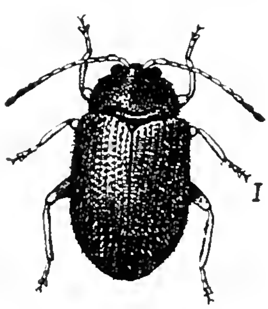

FIG. 65. — Potato Flea Beetle (*Epitrix cucumeris*). Adult beetle. (U. S. Bureau of Entomology.)

TOMATO PLUSIA (*Plusia rogationis*).

This is another caterpillar that feeds on the foliage of the tomato. It is about an inch and a quarter in length and is green in color, with a few longitudinal white stripes on the body. It is called a looper, from its peculiar method of locomotion, drawing the body up into a loop like a measuring worm each time it moves forward.

It develops rapidly and when full grown spins a silken cocoon in which it pupates. The adult moth is dark brown in color with two striking silvery spots in the middle of each front wing.

Control.—The larva is very heavily parasitized by a small hymenopteron, which keeps it so well under control that it seldom does serious damage. When numerous it may be controlled by spraying the plants with arsenate of lead three pounds in fifty gallons of water.

PLANT BUG (*Phthia picta*).

This large, dark-brown plant bug delights to sink its needle-like beak into the fruit of the tomato and suck the juices. The bright-red, wingless young congregate in groups on the developing fruit and distort it with their feeding punctures.

Control.—The best method of controlling this pest is to hand pick the adults and spray the nymphs with a soap and nicotine sulphate solution, prepared as recommended on page 268.

STINK BUGS.

A number of these so-called stink bugs are commonly found attacking the tomato vines. They are robust shield-shaped insects with sucking mouth parts, and are usually very inconspicuously colored. *Nezara viridula*, *Arvelius albopunctatus* and *Euschistus bifibulus* are the commonest of these.

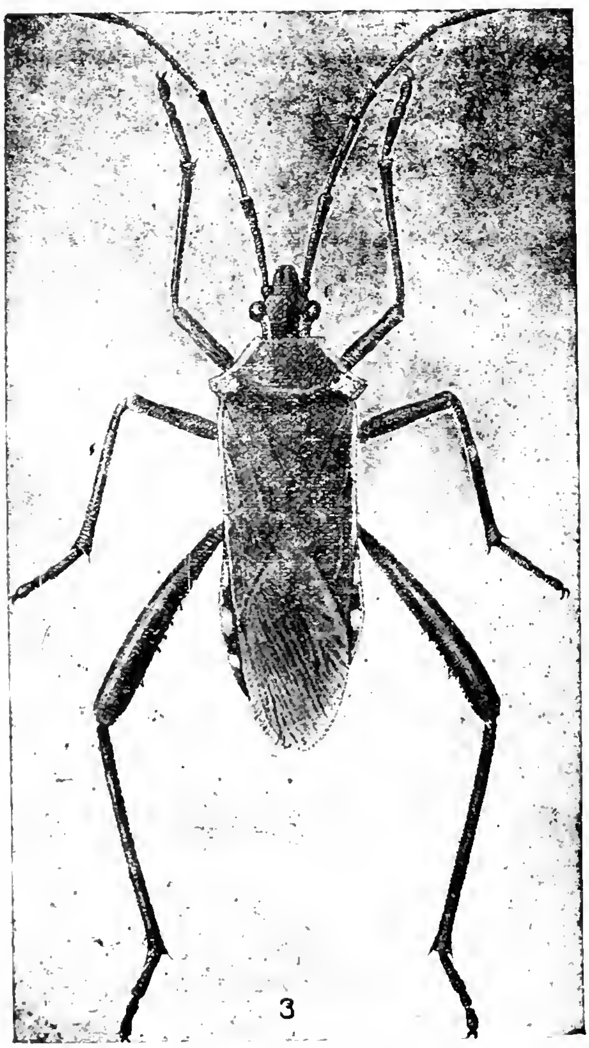

FIG. 66.—Plant Bug (*Phthia picta*). Adult male. Much enlarged. (U. S. Bureau of Entomology.)

While always to be found they are never numerous enough to cause serious damage, and control measures are not needed.

THE SUCK FLY

(*Dicyphus prasinus*).

The tomato is occasionally attacked by this slender bug, which injures the plant by sucking the juices from the stems and leaves.

This suck fly is pale green in color, and may be distinguished from allied species by the large fuscous spot that is present near the margin of each wingcover, midway between the base and apex.

The minute and inconspicuous flask-shaped eggs are inserted singly within the midrib of the leaf. The yellowish-green, wingless nymphs that emerge from the eggs suck the juices from the plants in the same manner as the adults. They pass through five nymphal stages before attaining adult form.

Control.—The nicotine sulphate and soap solution prepared as recommended on page 268, is effective in controlling this insect.

TOMATO FRUIT FLY.

This Anthomyid fly lays its small, white eggs in clusters on the fruit of the tomato. At times it is very abundant and deposits eggs on about fifty per cent of the fruit.

If the fruit is sound the small, white grubs that hatch from the eggs cannot gain entrance, but if there is the slightest wound or crack in the skin they penetrate to the soft pulpy interior, causing it to decay by their feeding activities.

Control.—All craked or decaying fruit should be collected and destroyed.

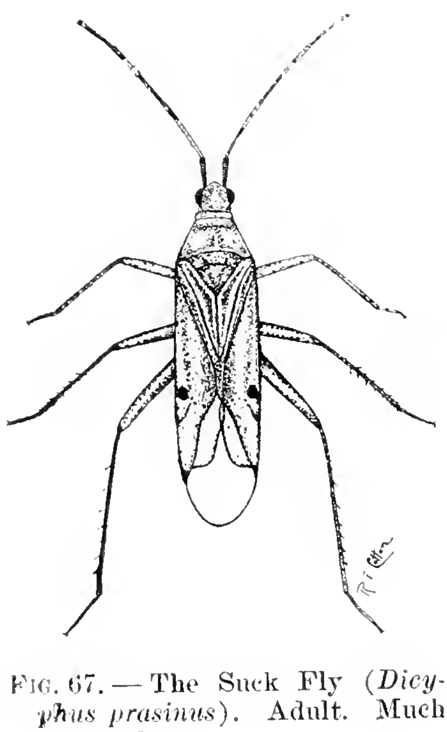

Fig. 67. — The Suck Fly (*Dicyphus prasinus*). Adult. Much enlarged.

OTHER TOMATO INSECTS.

Laphygma frugiperda, larva burrows in fruit (see Corn, page 288); *Leptoglossus gonogara* (see Squash, page 307); nematodes (see General Feeders, page 274); *Systena basalis* (see Carrots, page 284); *Xylomeges sunia*, defoliates plants (see Chard, page 287.

TURNIP.

The turnip is attacked by the same insects as the cabbage (see page 281).

YAUTIA.

THE LACE BUG (*Corythuca gossypii*).

This delicate little insect with its lacy white wings breeds in colonies on the undersides of the leaves of the *yautía*. The nymphs and adults feed by inserting their beaks into the tissue and sucking the juices. This causes the leaves to turn yellow and die.

Control.—Spray the undersides of the leaves with a nicotine sulphate and soap spray, prepared as recommended on page 268.

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[1] A general volume index has been considered unnecessary, each of the longer papers constituting the volume having been provided with one.

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